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ARITHMETIC OF PHARMACY

ARITHMETIC OF PHARMACY

BY

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SIXTH EDITION, REVISED AND ENLARGED BY

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PREFACE TO THE FOURTH EDITION

As in previous editions the use of higher mathematical terms has been avoided, and the analyses made as simple as possible that they may better serve the needs of the average student. Some subjects have been treated in a manner that may seem unnecessarily simple, but these may be omitted by the more advanced student.

The book was originally written as an aid to students not having had the advantages of a college education, and answers were given to nearly all the problems. Since then it has come into general use as text-book. Therefore, in deference to many teachers who use it, most of the answers have been omitted. The rules have also been omitted, with the hope that students will become more independent thinkers, instead of relying on the memory for certain rules.

The specific gravity and other data necessary for calculation of problems are usually given. Otherwise the student is referred to the last revision of the Pharmacopœia. Slight differences in results may be obtained due to the extent to which the decimals have been carried out. This is especially true in problems where the equivalents of weights and measures have been used.

Saturation tables have been added. These tables were first prepared by H. B. and C. W. Parsons for the U. S. P. VI, and were retained in U.S.P. VII and VIII. Dr. A. B. Lyons and the author revised them for the U. S. P. IX, but later the Committee decided to drop them. The author considered these tables too valuable to be lost and has therefore brought them up to date. Every pharmacist should become familiar with these tables, as by their use

many preparations may be extemporaneously made, and often time and money saved. They contain answers to 758 problems, from which teachers may select problems for special exercises.

A. B. STEVENS.

ANN ARBOR, MICHIGAN.

PREFACE TO THE FIFTH EDITION

In the present edition most of the data, such as specific gravity, per cent., molecular weights, etc., necessary for the solving of many problems, have been omitted from the body of the book, but may be found in the back of the book. If such information is given with each problem it at once suggests to the student that he must use the data given, while if it is not given he must think for himself, and thus become an independent worker.

Some portions of the book have been rewritten, new material added, and the number of problems nearly doubled.

The author is indebted to the following: Professor I. V. Stanley Stanislaus, Brooklyn College of Pharmacy, and Professor Elmer L. Hammond, Department of Pharmacy, West Virginia University, for helpful suggestions; to Professor Gordon A. Bergy, Department of Pharmacy, West Virginia University; to Professor Clifford C. Glover, College of Pharmacy, University of Michigan, and to Professor Charles H. Stocking, College of Pharmacy, University of Michigan, for suggestions and contributions of problems, and assistance in proof reading.

A. B. STEVENS.

ESCONDIDO, CALIFORNIA, 1926

PREFACE TO THE SIXTH EDITION

In preparing this edition, the revisors have followed the same general plan that has been used by the author in previous editions. The section on percentage solutions has been very largely rewritten to comply with the monograph on this subject which appears in the United States Pharmacopœia XI. Sections on commercial discount and profit and loss have been added. Tables of atomic and molecular weights have been corrected to date.

The revisors wish to express their sincere appreciation to Dr. Stevens for his cooperation and assistance in making this edition possible.

ANN ARBOR, MICH.
1936

C. H. STOCKING
J. L. POWERS

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ARITHMETIC OF PHARMACY

TABLES—WEIGHTS AND MEASURES

1. Metric System

The units of the metric system are Meter, Liter, Gram. The denominations above these units are expressed by adding the Greek prefixes Deka, 10; Hecto, 100; Kilo, 1000. The subdivisions are expressed by adding the Latin prefixes Deci, 0.1; Centi, 0.01; Milli, 0.001. The abbreviations of the units and multiples should begin with capitals, and those of the subdivisions with small letters.

Linear Measure		Volume		Weight		
Kilometer,	Km.	Kiloliter,	Kl.	Kilogram,	Kg.	1000.0
Hectometer,	Hm.	Hectoliter,	Hl.	Hectogram,	Hg.	100.0
Dekameter,	Dm.	Dekaliter,	Dl.	Dekagram,	Dg.	10.0
Meter,	M.	Liter,	L.	Gram,	Gm.	1.0
Decimeter,	dm.	Deciliter,	dl.	Decigram,	dg.	0.1
Centimeter,	cm.	Centiliter,	cl.	Centigram,	cg.	0.01
Millimeter,	mm.	Milliliter,	ml.	Milligram,	mg.	0.001

The prefixes Deka, Hecto, Deci and Centi are seldom used, their equivalents being expressed by use of multiples and subdivisions of their respective units, in the same manner that our decimal currency is expressed. It is customary to use cubic centimeter, cc., in place of the milliliter.

A cubic centimeter of distilled water when weighed in vacuo at 4° C. weighs 1 gram; when weighed in air at 15.6° C. it weighs 0.998 gram.

In ordinary practice, and throughout this book when changing weight to volume, and volume to weight, a cubic

centimeter is considered equivalent to one gram of distilled water. This is not strictly accurate. The error, at ordinary temperature, is approximately two grams to one liter, or 1 to 500.

All problems in this text, unless otherwise specified, are based on a standard temperature of 25° C.

2. Apothecaries Weight

20 Grains, gr.	=	1 Scruple, ℥.	
3 Scruples	=	1 Dram, ℥	= 60 Grains.
8 Drams	=	1 Ounce, ℥	= 480 Grains.
12 Ounces	=	1 Pound, lb.	= 5760 Grains.

Apothecaries weight is used only for compounding, and filling prescriptions.

The term "troy weight" is frequently incorrectly used when apothecaries weight is intended. Troy weights are used for weighing gems and precious metals. Its ounce and grain are the same as those of the apothecaries system.

3. Apothecaries Fluid Measure

Wine Measure

60 Minims, ℥	=	1 Fluidram, fl ℥.	
8 Fluidrams	=	1 Fluidounce, fl ℥	= 480 Minims.
16 Fluidounces	=	1 Pint, O	= 7680 Minims.
2 Pints	=	1 Quart, Qt.	
8 Pints	=	1 Gallon, Cong.	

The apothecaries fluidounce of distilled water weighs, in vacuo, at 4° C. (39.2° F.), 456.379 grains. It weighs in air, at 15.6° C. (60° F.), 455.7 grains. It weighs in air, at 25° C. (77° F.), 454.6 grains.

4. Avoirdupois Weight

437.5 Grains	= 1 Ounce, oz.	
16 Ounces	= 1 Pound, lb.	= 7000 Grains.

Avoirdupois weight is used entirely for buying and selling drugs, and for all other commercial transactions.

5. Imperial Measure

60 Minims, $\mathfrak{m}$	= 1 Fluidram, $\mathfrak{f}\mathfrak{z}$.
8 Fluidrams	= 1 Fluidounce, $\mathfrak{f}\mathfrak{z}$ = 480 Minims
20 Fluidounces	= 1 Pint, O
8 Pints	= 1 Gallon, Cong.

The Imperial gallon contains 10 avoirdupois pounds of distilled water at 15.6° C. The fluidounce therefore contains 437.5 grains.

The Imperial fluidounce and the apothecaries fluidounce contain the same number of drams and the same number of minims, but they differ in weight. The Imperial minim weighs 0.9114 of a grain and the apothecaries minim weighs 0.9493 of a grain.

6. Approximate Measures

One tumblerful equals about 8 fluidounces, or 240 cc.

One teacupful equals about 4 fluidounces, or 120 cc.

One wineglassful equals about 2 fluidounces, or 60 cc.

One tablespoonful equals about 4 fluidrams, or 16 cc.

One dessertspoonful equals about 2 fluidrams, or 8 cc.

One teaspoonful equals about 1 fluidram, or 4 cc.

One drop (L., gutta, pl. guttae, usually abbreviated, gtt.) is often considered as equal to about one minim, but the size of drops varies with the character of the liquid, the temperature and the surface from which it is dropped. In order to promote accuracy and uniformity in dosage the U. S. P. XI specifies that a medicine dropper shall have as

its delivery end an external diameter of 3 mm., and deliver 20 drops of distilled water, weighing 1 Gm., at a temperature of 15° C. This standard medicine dropper must be accurate to within 10 per cent.

7. Approximate Equivalents

The following equivalents are not exact, but are sufficiently accurate for all practical purposes. The approximate equivalents in bold face type should be memorized. From these the student should show the derivations of the others and verify the accuracy of each.

1 **Gram** = 15.432 Grains.

1 " = 0.035 Avoirdupois Ounce.

1 " = 0.032 Apothecaries Ounce.

1 **Cubic Centimeter** = 16.23 Apothecaries Minims.

1 " " = 16.9 Imperial Minims.

1 " " = 0.0338 Apothecaries Fluidounce.

1 " " = 0.035 Imperial Fluidounce.

1 **Liter** = 1.05668 Quarts.

1 **Kilogram** = 2.204 Avoirdupois Pounds.

1 **Grain** = 64.8 Milligrams.

1 " = 1.053 Minims.

1 " = 1.097 Imperial Minims.

1 **Meter** = 39.37 Inches.

1 **Inch** = 25.4 Millimeters.

1 **Yard** = 0.9144 Meter.

1 **Square Yard** = 0.83613 Square Meter.

1 **Cubic Inch** = 16.38716 Cubic Centimeters.

1 " " = 252.45 Grains.

1 **Apothecaries Ounce** = 31.1 Grams.

1 " " = 1.097 Avoirdupois Ounces.

1 " " = 1.053 Fluidounces.

1 **Avoirdupois Ounce** = 28.35 Grams.

1 " " = 0.911 Apothecaries Ounce.

1 " " = 0.961 Fluidounce.

1 " " = 1 Imperial Fluidounce.

1	Apothecaries Minim	= 0.9493 Grain.
1	“	“ = 1.04 Imperial Minims.
1	“	“ = 61.61 Milligrams.
1	“	Fluidounce = 29.57 Cubic Centimeters.
1	“	“ = 1.04 Avoirdupois Ounces.
1	“	“ = 0.95 Apothecaries Ounce.
1	“	“ = 1.04 Imperial Fluidounces.
1	“	Gallon = 231 Cu. Inches.
1	“	“ = 3.785 Liters.
1	Imperial Minim	= 0.9114 Grain.
1	“	“ = 0.96 Apothecaries Minim.
1	“	“ = 0.059 Cubic Centimeters.
1	“	Fluidounce = 28.35 Cubic Centimeters.
1	“	“ = 0.96 Apothecaries Fluidounce.

For scientific reasons most standards of weights and measures are obtained at maximum density in vacuo, but for practical purposes, such as taking specific gravities, preparing normal solutions, etc., a temperature of 25° C. under normal conditions has been adopted by the U. S. P. XI. However, the difference between the volume and weight of water amounts to only about four tenths of one per cent.

8. Addition, Subtraction, Multiplication, and Division of Weights and Measures

Abstract numbers increase and decrease in a tenfold ratio, while with compound numbers the scale varies with each denomination.

1. Example. *Add 4 pounds, 6 ounces, 5 drams, and 2 pounds, 8 ounces and 3 drams (apothecaries).*

4 lb.	6 oz.	5 dr.
2 “	8 “	3 “
7 “	3 “	

The sum of the first term is 8 dr. or 1 oz., which added to the next higher denomination makes 15 oz. or 1 lb. 3 oz. 1 lb. added to the next higher denomination makes 7 lb.

The operation may also be performed by reducing the terms to the same denomination and proceeding as in simple numbers, as follows:

$$\begin{array}{r}
 4 \text{ lb.} = 4 \times 12 \times 8 = 384 \text{ dr.} \\
 6 \text{ oz.} = 6 \times 8 = 48 \text{ " } \\
 2 \text{ lb.} = 2 \times 12 \times 8 = 192 \text{ " } \\
 8 \text{ oz.} = 8 \times 8 = 64 \text{ " } \\
 5 + 3 = 8 \text{ " } \\
 \hline
 696 \text{ " } = 7 \text{ lb. } 3 \text{ oz.}
 \end{array}$$

Problems

2. Add the following apothecaries weights:

5 lb.	4 $\overline{3}$	3 $\overline{3}$	2 $\overline{9}$	12 gr.
4 "	6 "	5 "	1 "	16 "
3 "	10 "	6 "	2 "	18 "

3. Add the following avoirdupois weights:

8 lb.	4 oz.	75 gr.
2 "	12 "	150 "
3 "	8 "	320 "

4. What is the weight of a mixture containing 4 apoth. ounces, 5 drams, 20 grains, 8 apoth. ounces, 410 grains, 7 drams and 50 grains?

5. What is the weight of Compound Powder of Senna formed by mixing the following: senna 6 apoth. ounces; glycyrrhiza 7 apoth. ounces, 6 drams, 40 grains; washed sulphur 2 apoth. ounces, 5 drams, 8 grains; oil of fennel 1 dram, 2 grains; and sucrose 16 apoth. ounces, 5 drams, 8 grains?

6. If you have in apothecaries weight 1 pound, 6 ounces and 240 grains of rhubarb and dispense 4 apoth. ounces and 2 drams at one time, and 3 apoth. ounces, 5 drams and 50 grains at another time, what weight in the apothecaries system will remain?

7. If you purchase a gallon of alcohol and sell at different times 1 ounce, $\frac{1}{2}$ pint, $2\frac{1}{2}$ ounces, 6 ounces, 2 pints, 4 ounces

and 6 drams, what volume expressed in apothecaries measure will remain?

8. What is the cost of 12 bars of soap at 30 cents a pound if each bar weighs 5 pounds and 6 ounces?

9. Divide 9 gallons, 8 pints and 10 ounces into 5 equal quantities.

10. If you dispense from an ounce of aspirin six 5 grain powders; at another time a dram and a half, and again two and a half drams, how many grains will you have left?

11. Divide 100 grains of sodium bicarbonate into 12 equal parts, and add to each 2 grains of sodium chloride. What will be the weight in grains of each powder?

12. A can contained one and a half gallons of glycerin, from which has been sold 1 pint, $3\frac{1}{2}$ fluidounces, and used in dispensing $1\frac{1}{2}$ pints, 4 fluidounces and 6 fluidrams. What volume expressed in apothecaries measure remains in the can?

13. If a gallon of a liquid pharmaceutical preparation requires 1 pound, 4 ounces and 6 drams of drug, how many gallons of mixture can be made from 12 pounds, 6 ounces and 6 drams of the drug?

9. Addition of Fractions

14. **Example.** *What is the weight of a powder that contains the following quantities of various substances: $\frac{3}{4}$ grain, $\frac{5}{6}$ grain, $\frac{7}{12}$ grain and $\frac{4}{18}$ grain?*

The fractions must be changed to their equivalents having a denominator common to all.

The least common denominator is a multiple of all the factors of the denominators.

$$\begin{array}{r}
 2) 4 - 6 - 12 - 18 \\
 \hline
 2) 2 - 3 - 6 - 9 \\
 \hline
 3) 1 - 3 - 3 - 9 \\
 \hline
 1 - 1 - 3
 \end{array}$$

The factors, 2, 2, 3, 3 contain all the factors of the denominators, and their multiple is the least common denominator, which is 36.

To change each fraction to its equivalent having a common denominator, both terms of the fraction must be multiplied by the quotient obtained by dividing the common denominator by the denominator of the fraction.

Thus:

$$\begin{array}{rcl}
 36 \div 4 = 9, & 9 \times 3 = 27 & 36 \div 6 = 6, \quad 6 \times 5 = 30 \\
 & 9 \times \overline{4} = \overline{36} & & 6 \times \overline{6} = \overline{36} \\
 36 \div 12 = 3, & 3 \times 7 = 21 & 36 \div 18 = 2, & 2 \times 4 = 8 \\
 & 3 \times \overline{12} = \overline{36} & & 2 \times \overline{18} = \overline{36}
 \end{array}$$

The sum of the numerators placed over the common denominator is the sum of the fractions.

Thus:

$$\frac{27}{36} + \frac{30}{36} + \frac{21}{36} + \frac{8}{36} = \frac{86}{36},$$

which, reduced to its simplest form, equals $2 \frac{7}{18}$ grains.

Problems

15. If you sell $\frac{1}{4}$ gallon of turpentine to one customer, $\frac{3}{5}$ of a gallon to another and $\frac{5}{8}$ of a gallon to another, how much will you have sold? Reduce the fraction in the answer to its lowest terms.

16. If you purchase $\frac{1}{4}$ interest in a store and later an additional $\frac{2}{5}$ interest, what part of the store would you then own?

17. If you sell $\frac{1}{6}$ of your store at one time and at another time $\frac{3}{8}$, what part of the store have you sold?

18. Having dispensed $\frac{1}{16}$ of an ounce of quinine at one time, $\frac{3}{12}$ of an ounce at another time and $\frac{1}{8}$ of an ounce at another time, what part of an ounce have you dispensed?

19. Having sold at different times $\frac{3}{5}$, $\frac{5}{6}$ and $\frac{1}{8}$ of a pint of glycerin, how many fluidounces have you sold?

10. Addition of Decimal Fractions

When adding decimal fractions write the decimals so that the decimal points will be in a perpendicular line, with

tenths under tenths, hundredths under hundredths, etc. Then add as in whole numbers.

20. **Example.** Add 0.045, 0.5, 0.125, 0.6435.

0.045
0.5
0.125
0.6435
1.3135

Problems

21. If you mix 0.25 of a pint of glycerin, 0.64 of a pint of bay rum and 0.7 of a pint of water, what will be the volume of the mixture?

22. Add 0.506, 0.72, 0.843.

23. Add 0.225, 0.654, 1.52.

24. What is the combined volume of 0.6, 3.15, 2.065 and 0.8502 cc. of water?

25. If you sell to one customer 2.5 fluidounces of glycerin, to another 4 fluidounces, and to another 3.6 fluidounces, how many fluidounces will you have sold?

11. Subtraction of Fractions

See that the fractions have a common denominator, as in the addition of fractions, then subtract the less numerator from the greater and place the difference over the common denominator.

26. **Example.** Subtract $2/5$ from $7/8$.

The common denominator of $2/5$ and $7/8$ is 40. $2/5 = 16/40$. $7/8 = 35/40$.

$$35/40 - 16/40 = 19/40.$$

Problems

27. If you own $5/8$ of a store and sell $1/6$ of the store, what fractional part do you still own?

28. If you have $\frac{3}{4}$ of a pint of ether and lose $\frac{1}{8}$ of a pint by evaporation, what fraction of a pint have you left?

29. If you have $1\frac{3}{8}$ pints of ammonia water and sell $\frac{4}{5}$ of a pint, how much have you left?

30. If you have a gallon and a half of glycerin and sell $\frac{2}{5}$ of a gallon and use $\frac{3}{10}$ of a gallon, what fraction of a gallon have you left?

31. If you sell $\frac{2}{5}$ of your store to one clerk and $\frac{3}{8}$ to another, what fractional part do you still own?

12. Subtraction of Decimal Fractions

Write the less number under the greater, in the same order as in addition of decimals, and subtract, as in whole numbers.

32. Example. Subtract 1.453 from 15.062.	15.062
	1.453
	13.609

Problems

33. If chlorinated lime contains 34.65 per cent. of available chlorine and has lost 13.85 per cent., what is its strength?

34. Subtract 0.3025 from 0.863.

35. If ammonia water contained 10.35 per cent. of NH_3 when purchased, but later was found to contain 6.95 per cent., what per cent. of NH_3 was lost?

36. Subtract 120.25 from 450.023.

13. Multiplication of Fractions

A fraction may be multiplied by multiplying its numerator, or by dividing its denominator.

37. **Example.** *Multiply $2/15$ by 5.*

$$\frac{5 \times 2}{15} = 10/15 = 2/3,$$

or

$$\frac{2}{15 \div 5} = 2/3.$$

To multiply a fraction by a fraction the numerators are multiplied together for the numerator of the product, and the denominators are multiplied together for the denominator of the product.

38. **Example.** *Multiply $3/5$ by $5/6$.*

$$3/5 \times 5/6 = \frac{3 \times 5}{5 \times 6} = \frac{15}{30} = \frac{1}{2}.$$

Problems

39. A physician prescribed 16 powders containing $1/6$ grain of calomel in each powder. How many grains of calomel were required?

40. If an elixir calls for $1/5$ grain of strychnine in the manufacture of 2 pints of elixir, what fractional part of a grain of strychnine will be required to make $4/5$ of a quart?

41. One gram is equal to $7/200$ of an avoirdupois ounce. What part of an avoirdupois ounce is $3/4$ of a gram equal to?

42. An avoirdupois ounce is equal to $28\frac{7}{20}$ grams. How many grams in $1\frac{4}{5}$ ounces?

43. A pharmacist owns a half interest in a store and sells three fourths of his interest. What fractional part of the whole did he sell?

44. If a carboy of acid is four fifths full and you use four fifths of this, how much will remain?

14. Multiplication of Decimal Fractions

Proceed as in whole numbers, and point off as many decimal places in the product as there are decimal places in the multiplier and multiplicand.

45. Example. *Multiply 3.52 by 0.86.*

3.525	
.86	

	21150
	28200

	3.03150

Problems

46. Multiply 0.023 by 0.62.
 47. What part of a grain of strychnine in 50 pills if each pill contains 0.002 of a grain?
 48. Multiply 1.084 by 43.426.
 49. Pills of phosphorus should contain 0.0006 of a gram in each pill. What part of a grain of phosphorus will be required to make 125 pills?
 50. Multiply 445.524 by 0.781.

15. Division of Fractions

A fraction may be divided by dividing its numerator or multiplying its denominator.

51. Example. *Divide 6/12 by 3.*

$$6/12 \div 3 = \frac{6 \div 3}{12} = \frac{2}{12} = \frac{1}{6},$$

or

$$6/12 \div 3 = \frac{6}{12 \times 3} = \frac{6}{36} = \frac{1}{6}.$$

To divide a fraction by a fraction, invert the terms of the divisor and proceed as in multiplication.

52. Example. *Divide 3/4 by 2/3.*

$$3/4 \div 2/3 = \frac{3}{4} \times \frac{3}{2} = \frac{9}{8} = 1\frac{1}{8}.$$

Problems

53. The dose of an alkaloid is $\frac{3}{50}$ of a grain. How many doses can be obtained from $\frac{9}{10}$ of a grain?

54. How many $\frac{1}{50}$ grain doses can be obtained from $\frac{4}{5}$ of a grain of apomorphine hydrochloride?

55. How many $\frac{1}{400}$ grain doses of aconitine can be obtained from $\frac{3}{80}$ of a grain of aconitine?

56. A physician prescribes a mixture calling for $\frac{3}{25}$ of a grain of atropine. How many $\frac{1}{50}$ grain tablets may be used instead of weighing out the alkaloid?

57. How many powders containing $\frac{3}{8}$ of a grain of mercurous chloride can be made from $4\frac{1}{2}$ grains of the chloride?

58. Divide $\frac{5}{6}$ of a grain of atropine into 45 doses. What will be the weight of each?

16. Division of Decimal Fractions

Divide as in whole numbers and point off as many decimal places as those in the dividend exceed those in the divisor.

59. Example. *Divide 10.695 by 2.3.*

$$10.695 \div 2.3 = 4.67.$$

Problems

60. How many 0.15 gram doses can be dispensed from 2.45 grams of caffeine?

61. How many 0.06 gram doses can be obtained from 1.44 grams of ipecac?

62. How many 0.03 gram powders can be made from 0.48 gram of codeine?

63. How many 0.008 gram doses can be dispensed from 0.192 gram of morphine?

64. How many 0.0006 gram doses can be dispensed from 0.0072 gram of hyosecyamine hydrobromide?

17. To Change Decimal Fractions to Common Fractions

Decimal fractions may be changed to common fractions by simply writing the decimal in the form of a common fraction and reducing to its lowest term.

65. Example. *Change 0.75 to a common fraction.*

Thus:

$$0.75 = \frac{75}{100} = \frac{3}{4}.$$

66. Example. *Change 0.0125 to a common fraction.*

$$0.0125 = \frac{125}{10000} = \frac{5}{400} = \frac{1}{80}.$$

The fraction $\frac{125}{10000}$ was reduced to $\frac{5}{400}$ by dividing both terms by 25, and $\frac{5}{400}$ was reduced to $\frac{1}{80}$ by dividing both terms by 5.

Note that the figures of the decimal form the numerator, and the denominator is 1 with as many ciphers added as there are characters to the right of the decimal point.

Problems

67. If the dose of strychnine is 0.025 of a grain, what would be the dose in common fractions?

Convert the following decimals to common fractions.

68. 0.6

72. 0.25

76. 0.024

69. 0.08

73. 0.2

77. 0.35

70. 0.64

74. 0.16

78. 0.72

71. 0.125

75. 0.004

18. To Change Common Fractions to Decimal Fractions

Divide the numerator by the denominator expressed decimally.

79. Example. *Change $3/4$ to a decimal fraction.*

Thus:

$$\frac{3}{4} = 3 \div 4 = 0.75.$$

Problems

The following fractional doses may be found in the U. S. P. Change them to decimal form.

80. $\frac{1}{6}$

82. $\frac{1}{15}$

84. $\frac{1}{12}$

86. $\frac{1}{200}$

81. $\frac{1}{20}$

83. $\frac{1}{16}$

85. $\frac{1}{400}$

87. $\frac{1}{8}$

19. To Change a Fraction of One Denomination of Weights and Measures to Lower Denominations

When working problems many answers contain a fraction. These can often be eliminated by multiplying the fraction by the number of units of a lower denomination that is required to make one of the given denomination.

88. Example. *Remove the fraction from 2.8 pints.*

Eight tenths of a pint is reduced to ounces by multiplying by 16, the number of ounces in one pint, which gives 12.8 ounces. Eight tenths of an ounce is reduced to drams by multiplying by 8, the number of drams in one ounce, which gives 6.4 drams. The four tenths of a dram is reduced to minims by multiplying by 60, the number of minims in a dram, which gives 24 minims.

2.8 pints = 2 pints, 12 ounces, 6 drams and 24 minims.

Problems

89. Reduce $1/6$ of a gallon to its lower denominations.

90. Change 0.325 of a pint to its lower denominations.

91. How many minims in 1.65 fluidounces?
92. Remove the fractions from 1.24 Imperial fluidounces.
93. How many grains in 2.258 avoirdupois ounces?
94. How many grains in $\frac{2}{5}$ of an apothecaries ounce?
95. Change $\frac{3}{8}$ of a fluidounce to minims.
96. Change $\frac{4}{5}$ of a pint to lower denominations.
97. What is the equivalent, in wine measure, of 612 cubic centimeters?

20. To Determine Quantities Used in Manufacturing

98. **Example.** *How many grams of each ingredient are required in the manufacture of 35 grams of Compound Chalk Powder? The U. S. P. gives the following proportions:*

Prepared Chalk.....	30 Gm.
Acacia.....	20 Gm.
Sucrose.....	50 Gm.

To make 100 Gm.

The quantity to be made, 35 grams, is $\frac{35}{100}$ of 100 grams, the amount of the formula. Hence we must take $\frac{35}{100}$ of the amount given for each ingredient, and we have as follows: Prepared chalk 10.5 grams, acacia 7 grams, and sugar 17.5 grams. Reference should be made to the United States Pharmacopoeia, XI and the National Formulary VI, for the official preparations listed among the problems below.

Problems

How much of each ingredient must be used in the manufacture of the following pharmacopœial preparations:

99. To make 120 pills of Ferrous Carbonate?
100. To make 300 grams of Compound Powder of Senna?
101. To make 1250 cc. of Syrup of Orange?
102. To make 6.5 liters of Aromatic Elixir?
103. If you wish to use 11 grams of mercury in the manufacture of Mass of Mercury, how much of the other constituents must be used?

Note.—Proceed as above, except that the quantity of mercury to be used is divided by the quantity of mercury given in the formula. The quantities of the other ingredients are multiplied by this quotient.

104. How many grams of opium and lactose must be mixed with 25 grams of ipecac to make Dover's Powder?

105. How many cubic centimeters of Spirit of Peppermint can be prepared from one fluidounce of oil of peppermint?

106. How many grains of atropine will be required to make 1000 tablets containing one sixty-fourth of a grain each?

107. How many grains in 0.36 of an avoirdupois ounce?

108. When codeine sulphate costs \$12.75 an ounce, in $\frac{1}{8}$ oz. vials, what will one dram cost?

109. When quinine benzoate costs \$1.26 an ounce, what will 25 grains cost?

110. What quantity of each ingredient is required to compound the following prescription:

R	Quininæ sulphatis	gr. ij
	Ferri reducti	gr. j
	Acidi arsenosi	gr. $\frac{1}{40}$
	Strychninæ sulphatis	gr. $\frac{1}{60}$
	Pulveris ipecacuanhæ	gr. $\frac{1}{8}$
	For one pill. Make 120 such pills.	

21. To Change Weights and Measures from One System to Those of Another

Troy, apothecaries and avoirdupois weights, wine and Imperial measures may be changed from one to the other by reducing the different terms of the system, of which the quantities are given, to grains and dividing by the number of grains in the terms of the desired system.

111. *Example. Convert 10 ounces and 2 drams apothecaries weight into avoirdupois weight.*

Since there are 480 grains in 1 apothecaries ounce, there are 4800 grains in 10 ounces. In 2 drams there are 120

grains. $4800 \text{ gr.} + 120 \text{ gr.} = 4920 \text{ gr.}$, and $4920 \text{ gr.} \div 437.5$ (the number of grains in an avoirdupois ounce) = 11 avoirdupois ounces and 107.5 grains.

Problems

112. Change 5 pints wine measure to Imperial measure.

$$\frac{5 \times 16 \times 454.6}{437.5} = 83.126 \text{ oz. or 4 pints, 3 fl. ounces, 1 fl. dr.,}$$

and 0.48 m

113. Change 7 pounds, 8 ounces avoirdupois to apothecaries weight.

114. Change 29 ounces apothecaries weight to avoirdupois weight.

115. Convert 1 gallon wine measure into Imperial measure.

116. Convert 4 Imperial pints into wine measure.

117. Change 6 avoirdupois pounds to wine measure.

118. Change 60 apothecaries ounces to wine measure.

119. Change 10 wine gallons to avoirdupois weights.

22. To Change Weights and Measures from One System to Those of Another by the Use of Equivalents

(See Approximate Equivalents, Page 4)

120. Example. *Change 10.5 apothecaries ounces to avoirdupois ounces.*

The equivalent of one apothecaries ounce is 1.097 avoirdupois ounces. Hence $10.5 \times 1.097 = 11.518$ or approximately $11\frac{1}{2}$ avoirdupois ounces.

The results obtained by the use of equivalents are not quite as accurate as by the preceding method, but are sufficiently accurate for practical purposes.

Compare the answers to the following problems with those obtained when working the same problems by the preceding method.

Problems

121. Change 5 wine pints to Imperial measure.
 $5 \times 16 \times 1.04 = 83.2$ oz. or 4 pts., 3 oz., 1 dr., 36 m
122. Convert 18 fluidounces into cubic centimeters.
123. What is the weight in grains of 75 minims of water?
124. How many minims are the equivalent of 170 grains of water?
125. Convert 6000 cubic centimeters into fluidounces.
126. Change 800 grams to avoirdupois weight.
127. Convert 12 avoirdupois ounces into grams.
128. Convert 580 grams into apothecaries weight.
129. Convert 7.5 apothecaries ounces into grams.
130. What is the volume in apothecaries measure of 10 avoirdupois pounds of water?
131. What is the avoirdupois weight of a gallon of water?
132. How many cubic centimeters are there in a gallon of water?
133. What is the cost of 12, 2-grain powders of codeine sulphate when one ounce costs \$5.30?
134. The 1914 British Pharmacopœia formula for Syrup is: "Refined sugar, 5 pounds; boiling distilled water, 2 pints. Heat until dissolved, and add boiling distilled water to 7.5 pounds." Change the quantities to apothecaries weight and wine measure.
135. Change the following to apothecaries weight and wine measure, giving your answer in compound denominate quantities.

Belladonna Liniment

Camphor 50 Gm.

Fl. Ext. Belladonna to make 1000 cc.

136. Change the following formula for camphor and soap liniment to Imperial weights and measures:

Soap 60 Gm.

Camphor 45 Gm.

Oil Rosemary 10 cc.

Alcohol 700 cc.

Water to make 1000 cc.

137. Change the following prescription to the Metric system:

℞ Acetanilidigr. xxxvj
 Potassii bromidigr. xxiv
 Caffeinæ citratgr. xij
 Divide in 12 powders.

138. Change to apothecaries weights and measures.

℞ Codeinæ sulphatis 0.13 Gm.
 Ammonii chloridi 8. Gm.
 Syrupi tolutani 60. cc.
 Aquæad 90. cc.

23. To Calculate Dosage of Medicinal Ingredients in Prescriptions

Too much importance cannot be placed upon the necessity for extreme accuracy in all the calculations involved in the filling of prescriptions. Problem 110 illustrates the method by which the physician builds up the prescription from the standpoint of the dose of each ingredient, indicating the total number of doses to be prepared by the pharmacist. The amount of each medicinal material to be taken at a single dose can be observed at a glance, and the total quantity of each ingredient to be used in filling the prescription can be found by simple multiplication. Prescriptions for pills, powders and capsules are frequently written in this manner. Liquid prescriptions, on the other hand, are practically always written to indicate the total amount of each ingredient in a given volume. In order to calculate the dose of each ingredient, the pharmacist must first determine the total number of doses in the prescription and then divide the indicated quantity of each ingredient by this figure.

139. Example. *What is the dose of each ingredient in the following prescription?*

℞ Sodii bromidigr. clx
 Potassii bromidigr. lxiv
 Aquae destillatae....q.s. ad.....fl. oz. iv
 Sig. Teaspoonful at bed time.

Each teaspoonful represents approximately one fluid dram. There are eight drams in one fluid ounce. Four (the number of fluid ounces in the prescription) multiplied by eight, equals thirty-two, the number of fluid drams, or *doses*, in the prescription. One hundred and sixty divided by thirty-two equals five, or the number of grains of sodium bromide in each dose. By a similar process, the dose of potassium bromide can be determined. It should be borne in mind that doses of less than one minim or less than one grain should always be expressed in the form of common fractions, whereas doses, large or small, in the metric system are always expressed as decimal fractions.

Doses for children are most commonly calculated by means of *Dr. Young's Rule*. By this rule, the age of the child in years divided by the age plus twelve constitutes the fraction of the adult dose which should be given to the child.

Children are very susceptible to narcotics, and, therefore, should be given smaller doses of opium and other narcotic drugs than Young's Rule would indicate. Laxatives may be given in somewhat larger doses than indicated.

140. Example. If the adult dose of a drug is eight grains, how many grains of that drug should be given to a four-year-old child?

$$\frac{4}{4 + 12} = \frac{4}{16} = \frac{1}{4}$$

$\frac{1}{4} \times 8 = 2$, the dose for a four-year-old child.

Problems

141. $\mathcal{R}$ Extracti colocynthisgr. iv
 Aloesgr. xlvij
 Resinæ scammoniigr. xxxvj
 Olei caryophylligr. vj
 Divide into 24 pills.

142. $\mathcal{R}$ Strychninæ nitratis gr. ij
 Liquoris acidi arsenosi fl. dr. ij
 Aquæq. s. ad fl. oz. iij
 S. Teaspoonful three times a day.

143. How many grains of corrosive sublimate in one pint of a 1-1000 solution?

144. How many 12.5 grain doses are there in one fourth pound of chloral hydrate?

145. If 500 cubic centimeters of a solution contains 125 grams of potassium bromide, and 4 cc. are taken at a dose, how much potassium bromide will such a dose contain?

146. If the adult dose of Oleoresin of Aspidium is one fluid drachm, how many minims should be prescribed for a child eight years old?

147. If the adult dose of a drug is five grains, how many grains should be given to a child six months old?

148. The adult dose of a drug is .015 Gm. What fractional portion of a gram of this drug should be prescribed for a child three years old?

149. If twelve grains of a certain drug are dissolved in sufficient solvent to make three fluid ounces of solution, how many grains of the drug will there be in each dose if the patient is to take a half teaspoonful three times daily?

150. $\mathcal{R}$ Ammonii chloridi ʒ ss
 Syrupi scillæ ʒ jss
 Syrupi ipecacuanhæ ʒ vi
 Syrupi pruni virginianæq. s. ad ʒ vi
 M. Sig. One dessertspoonful every three hours.

How many grains of ammonium chloride in each dose? How many minims of syrup of squill and of syrup of ipecac in each dose?

151. If 500 cc. of Elixir of Iron, Quinine and Strychnine contain 87.5 milligrams of strychnine sulphate and the dose of the elixir is 4 cc., how many milligrams of strychnine sulphate in each dose?

152. R	Fluidextracti rhei	1	5
	Fluidextracti ipecacuanhæ		3
	Sodii bicarbonatis	3	5
	Spiriti menthæ piperitæ	2	5
	Glycerini	20	
	Aquæ destillatæ	q. s. ad	100
	M. Sig. 4 cc. t. i. d.		

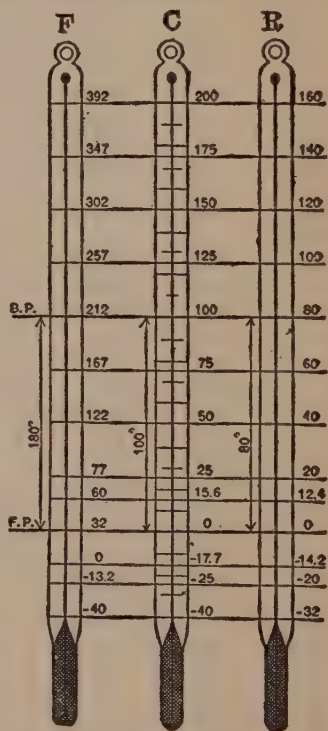
What is the metric dose of each of the first four ingredients in the above prescription?

THERMOMETERS—TEMPERATURE

Three kinds of thermometers are used for measuring heat: Fahrenheit, Centigrade, and Réaumur. The first is the domestic thermometer of the United States and Great Britain. The second is used for scientific purposes; the third is rarely used in this country.

The boiling point of water is 212° F., 100° C., 80° R. The freezing point of water is 32° F., 0° C., 0° R. The difference between the freezing and the boiling points of water is 180° F., 100° C., and 80° R.

A good idea of the construction of the scales of different thermometers may be obtained by studying the illustration. The zero of the Fahrenheit thermometer is 32 degrees below the zero of other thermometers. It is therefore necessary to subtract 32 from Fahrenheit degrees, before multiplying by the equivalent, when changing to other degrees. And for the same reason, 32 degrees must be added, after multiplying by the equivalent, when changing to Fahrenheit.



Several methods are in use for the conversion of the degrees of one system into those of another. They are derived from the number of degrees between the freezing and boiling points of water of the different scales.

24. To Convert Fahrenheit to Centigrade

153. Example. *Convert 140° Fahrenheit to Centigrade.*

We have seen that the difference between the freezing and the boiling point of water is 180 degrees for the Fahrenheit, and 100 degrees for the Centigrade. Hence 180 degrees Fahrenheit is equal to 100 degrees Centigrade. Or, $1.8^{\circ} \text{ F.} = 1^{\circ} \text{ C.}$ Therefore, to change Fahrenheit to Centigrade subtract 32 and divide by 1.8.

Thus: $140^{\circ} - 32^{\circ} \div 1.8 = 60^{\circ}.$

Or, subtract 32 and multiply by $5/9$, which is the reciprocal of 1.8 in the form of a common fraction.

Thus: $140^{\circ} - 32^{\circ} \times 5/9 = 60^{\circ}.$

Or, add 40, divide by 1.8 and subtract 40.

Thus: $140^{\circ} + 40^{\circ} \div 1.8 - 40^{\circ} = 60^{\circ}.$

The same procedure is followed when changing minus degrees Fahrenheit to Centigrade.

154. Example. *Change Minus 4 degrees Fahrenheit to Centigrade.*

If we subtract a number from an already negative quantity we increase the negative quantity by the amount that is to be subtracted. Therefore, to subtract 32 from minus 4 we must add 32 which gives -36 . Minus 36 divided by $1.8 = -20$, or 20 degrees below zero Centigrade.

Thus: $-4^{\circ} - 32^{\circ} = -36^{\circ}, -36^{\circ} \div 1.8 = -20^{\circ}.$

155. Example. *Change 23 degrees Fahrenheit to Centigrade.*

If we subtract 32 degrees from 23° we will have as many degrees below zero as the difference between 23 and 32 which is 9° . Minus 9° divided by 1.8 gives -5° C.

Thus: $23^{\circ} - 32^{\circ} = -9^{\circ}, -9^{\circ} \div 1.8 = -5^{\circ}.$

Problems

156.	Convert	68°	Fahrenheit	to	Centigrade.
157.	"	23°	"	"	"
158.	"	— 22°	"	"	"
159.	"	390°	"	"	"
160.	"	244°	"	"	"
161.	"	— 40°	"	"	"
162.	"	70°	"	"	"

25. To Convert Centigrade to Fahrenheit

163. Example. *Convert 210° Centigrade to Fahrenheit.*

Since 1° C. is equal to 1.8° F., to change Centigrade degrees to Fahrenheit multiply by 1.8 and add 32 degrees.

Thus: $210^{\circ} \times 1.8 + 32^{\circ} = 410^{\circ}$.

Or, multiply by $9/5$ and add 32.

Thus: $210^{\circ} \times 9/5 + 32^{\circ} = 410^{\circ}$.

Or, add 40, multiply by 1.8 and subtract 40.

Thus: $210^{\circ} + 40^{\circ} \times 1.8 - 40^{\circ} = 410^{\circ}$.

The same methods apply when changing minus degrees Centigrade to Fahrenheit.

164. Example. *Change Minus 25° Centigrade to Fahrenheit.*

Minus 25 degrees multiplied by 1.8 gives minus 45; to which must be added 32. If we add a number to a negative quantity we decrease the negative quantity by the amount that is to be added. Therefore, to add 32 to minus 45 we must subtract 32 from 45, which leaves minus 13, or 13 degrees below zero Fahrenheit.

Thus: $-25^{\circ} \times 1.8 + 32^{\circ} = -13^{\circ}$.

165. Example. *Change Minus 5° Centigrade to Fahrenheit.*

Minus 5 multiplied by 1.8 gives minus 9. If we add 32 to minus 9 we destroy the negative factor and have 23 left, or 23 degrees above zero Fahrenheit.

Thus: $-5^{\circ} \times 1.8 = -9^{\circ}$, $-9^{\circ} + 32 = 23^{\circ}$.

Problems

166. Convert 250° Centigrade to Fahrenheit.

167. " — 40° " " "

168. " 30° " " "

169. " — 10° " " "

170. " — 30° " " "

171. " — 4° " " "

172. " 22° " " "

26. To Convert Fahrenheit to Réaumur

173. Example. Convert 77° Fahrenheit to Réaumur.

Since there are only 80° between the freezing and boiling point on the Réaumur scale, one degree Fahrenheit is equal to 80/180, or 4/9 of a degree Réaumur. Therefore to change Fahrenheit to Réaumur subtract 32 and multiply by 4/9.

Thus: $77^{\circ} - 32^{\circ} \times 4/9 = 20^{\circ} \text{ R.}$

Problems

174. Convert 95° Fahrenheit to Réaumur.

175. " — 13° " " "

176. " 23° " " "

177. " 70° " " "

27. To Convert Réaumur to Fahrenheit

178. Example. Convert 80° Réaumur to Fahrenheit.

One degree Réaumur is equal to 180/80, or 9/4 degrees Fahrenheit. Therefore to change Réaumur to Fahrenheit multiply by 9/4 and add 32.

Thus: $80 \times 9/4 + 32 = 212^{\circ} \text{ F.}$

Problems

179. Convert 32° Réaumur to Fahrenheit.

180. " 96° " " "

181. " — 16° " " "

182. " — 8° " " "

183. " 14° " " "

28. To Convert Centigrade to Réaumur

184. **Example.** *Convert 80° Centigrade to Réaumur.*

One degree Centigrade is equal to 80/100, or 4/5 of a degree Réaumur. Therefore to change Centigrade to Réaumur multiply by 4/5.

Thus: $80 \times 4/5 = 64^\circ \text{R.}$

Problems

185. Convert 72.5° Centigrade to Réaumur.

186. " 350° " " "

187. " - 40° " " "

188. " 25° " " "

29. To Convert Réaumur to Centigrade

189. **Example.** *Convert 80° Réaumur to Centigrade.*

One degree Réaumur is equal to 100/80, or 5/4 degrees Centigrade. Therefore to change Réaumur to Centigrade multiply by 5/4.

Thus: $80 \times 5/4 = 100^\circ \text{C.}$

Problems

190. Convert 640° Réaumur to Centigrade.

191. " 48° " " "

192. " - 12° " " "

30. Individual Scale for Thermometers

Professor Bergy recommends that the student be given the freezing and boiling point for an individual scale, and that he be required to develop the equivalent for other thermometers.

For example, the freezing point on the B thermometer may be zero, and the boiling point 500. Let the student determine the equivalent to be used in converting B degrees into degrees on other thermometers.

A number of different scales may be given. The following are a few suggestions.

A	Scale	Freezing point	60°	boiling point	300°
D	"	"	"	40°	"
E	"	"	"	0°	"
G	"	"	"	50°	"
					400°
					250°
					200°

Problems

193. What equivalent must be used to convert degrees on the D scale to Fahrenheit degrees?

194. What equivalent must be used to convert degrees on the E scale to Centigrade degrees?

195. What equivalent must be used to convert Fahrenheit degrees to A scale degrees?

196. What equivalent must be used to convert Fahrenheit degrees to E scale degrees.

197. What equivalent must be used to convert Centigrade degrees to G scale degrees?

198. What equivalent must be used to convert degrees on the G scale to degrees on the B scale?

199. When the temperature is 50° C. what is the corresponding temperature on the B scale?

200. When the temperature is 75° on the B scale what is the temperature on the C. and F. thermometers?

201. Convert 150 degrees Fahrenheit to the B scale.

202. Convert 20° D to F 209. Convert 20° F to D

203. " 30° C " D 210. " 60° D " C

204. " — 10° F " D 211. " — 12° F " D

205. " 30° A " F 212. " 20° F " A

206. " 350° A " F 213. " 90° F " A

207. " — 25° C " A 214. " 40° A " C

208. " — 15° B " F 215. " — 10° F " A

The teacher can give any number of additional problems, as he is only limited by the number of degrees on the thermometer.

SPECIFIC GRAVITY

It is not the purpose of this work to enter into the details of taking specific gravity, but rather to give problems illustrating the methods of calculating the results of manipulation.

Specific gravity may be defined as the relative weight of equal bulks or volumes of different bodies, water being taken as the standard. The object sought is always the weight of a volume of water equal to that of the substance the specific gravity of which we wish to obtain, whether that substance be liquid or solid, soluble or insoluble, heavier or lighter than water. The specific gravity is then obtained by *dividing the weight of the substance by the weight of an equal volume of water*.

31. Specific Gravity Hydrometers

The specific gravity of liquids is usually taken with hydrometers or specific gravity flasks (pycnometers).

Hydrometers are instruments which, when floating in a liquid, show the specific gravity, density, or per cent., on a scale. The specific gravity hydrometer is so constructed that the number at the surface of the liquid represents the specific gravity. Hydrometers for liquids heavier than water are graduated from 2000 at the bottom to 1000 at the top. That the reading may be more exact, it is customary to use five hydrometers for liquids heavier than water. The first is graduated from 1000 to 1200, the second from 1200 to 1400, the third from 1400 to 1600, the fourth from 1600 to 1800, and the fifth from 1800 to 2000.

For liquids lighter than water, the hydrometer is graduated from 1000 at the bottom to 700 at the top.

The specific gravity hydrometer should sink in pharmacopœial hydrochloric acid to 1155, in sulphuric acid to 1830, in alcohol to 816 and in ether to 716. By pointing off three decimal places, if the instrument is not so marked, we have the respective specific gravities without calculation.

Hydrometers giving the per cent. by weight or volume are constructed for special purposes, as alcoholometers, which are so graduated that the reading gives the actual per cent. of absolute alcohol that the liquid contains.

Baumé hydrometers are constructed for use in both light and heavy liquids. The scale gives arbitrary degrees, which may be converted into specific gravity as follows:

32. To Change Baumé Degrees to Specific Gravity for Liquids Heavier than Water

216. **Example.** *Change 60° Baumé to specific gravity.*

$$\frac{145}{145 - 60} = \frac{145}{85} = 1.7058 \text{ sp. gr.}$$

Problems

217. What is the specific gravity of hydrochloric acid, 20° Baumé?

218. To what point will a specific gravity hydrometer sink in glycerin when a Baumé hydrometer sinks to 29°?

219. What is the specific gravity of sulphuric acid, 45° Baumé?

220. If a Baumé hydrometer sinks to 35° in a solution of sucrose what is the specific gravity of the syrup?

33. For Liquids Lighter than Water

221. **Example.** *Change 56° Baumé to specific gravity.*

$$\frac{140}{130 + 56} = \frac{140}{186} = 0.752 \text{ sp. gr.}$$

Problems

222. What is the specific gravity of ammonia water, 24° Baumé?
 223. If an oil has a density of 15 degrees Baumé, what is its specific gravity?
 224. What is the specific gravity of ether at 56.6 degrees Baumé?
 225. What is the specific gravity of alcohol, 40° Baumé?
 226. Change 60° Baumé to specific gravity.

34. To Change Specific Gravity to Baumé Degrees for Liquids Lighter than Water

227. *Example. Change specific gravity 0.750 to Baumé degrees.*

$$\frac{140}{0.750} - 130 = 56.66^\circ \text{ Bé.}$$

Problems

228. What is the degree Baumé of ammonia water which has a specific gravity of 0.9655?
 229. Change the following specific gravities to Baumé degrees: 0.765, 0.979, 0.909, 0.800.
 230. What is the Baumé density of ether which has a specific gravity of 0.713?
 231. Oleic acid has a specific gravity of 0.89. What is its equivalent in Baumé degrees?
 232. What are the Baumé degrees of aromatic spirit of ammonia which has a specific gravity of 0.90?
 233. If spirit of glyceryl trinitrate has a specific gravity of 0.82, what would be its Baumé degrees?

35. For Liquids Heavier than Water

234. *Example. Change specific gravity 1.24 to Baumé degrees.*

$$145 - \frac{145}{1.24} = 28.1^\circ \text{ Baumé.}$$

Problems

235. How many degrees Baumé is sulphuric acid which has a specific gravity of 1.84?

236. What are the degrees Baumé of a syrup having a specific gravity of 1.124?

237. Change specific gravities 1.576 and 1.45 to Baumé degrees.

238. Hydrobromic acid has a specific gravity of 1.155. What are its Baumé degrees?

239. Solution of Ferric Sulphate has a specific gravity of 1.432. What are its degrees Baumé?

240. What are the Baumé degrees of lactic acid having a specific gravity of 1.206?

241. Chloroform has a specific gravity of 1.475. What are its Baumé degrees?

36. To Change Twaddell Degrees to Specific Gravity

Twaddell's hydrometer is for liquids heavier than water. Each degree equals 0.005 of a specific gravity degree. Therefore to change Twaddell degrees to specific gravity multiply by 0.005 and add one for the specific gravity of water.

242. *Example.* What is the specific gravity of sulphuric acid if Twaddell's hydrometer floats at 168°?

$$168 \times 0.005 + 1 = 1.84 \text{ specific gravity.}$$

Problem

243. Change the following Twaddell's degrees to specific gravity: 50°, 80°, 125°, 20° and 35°.

37. To Change Specific Gravity to Twaddell Degrees

This is just the opposite of the preceding operation. Therefore we must subtract one and divide by 0.005.

244. Example. *What degree, Twaddell, is hydrochloric acid, specific gravity 1.16?*

$$\frac{1.16 - 1}{0.005} = 32^{\circ} \text{ T.}$$

Problem

245. To what degree will a Twaddell's hydrometer sink in the following pharmacopœial preparations: Nitric acid, solution ferric chloride, syrup, sulphuric acid and glycerin?

38. Specific Gravity Flasks or Pycnometers

The majority of specific gravity flasks are constructed to hold 25, 50 or 100 grams at a given temperature, and in some cases 250, 500 and 1000 grains, but the latter are rapidly passing out of use. When the flask holds exactly 100 grams of water at the proper temperature, the same flask will hold 71.6 grams of ether or 147 grams of chloroform, which, if divided by 100, will give the specific gravity of each liquid. Therefore, when the same flask is filled with any liquid, we have only to divide the weight of the contents of the flask by 100 to obtain the specific gravity. In like manner, if the flask contains 25 grams of water we have only to multiply the weight of its contents, when filled with *any liquid*, by 0.04, or to divide by 25, to obtain the specific gravity.

An ordinary light flask holding from 20 to 100 cc. may be used in taking the specific gravity of liquids. The flask is dried and weighed, filled with water at the proper temperature and weighed again, and the weight of the flask subtracted; the difference is the weight of the water. In the same manner find the weight of the contents of the flask when filled with any desired liquid.

246. Example. *A flask weighs 20 grams; when filled with water it weighs 44 grams, and when filled with glycerin 50 grams. What is the specific gravity of the glycerin?*

Subtracting the weight of the bottle in each case, we have 24 grams as the weight of the water and 30 grams as the weight of the glycerin. $30 \div 24 = 1.25$ the sp. gr. of the glycerin.

Problems

247. How many grams of glycerin, sp. gr. 1.25, will a 100 cc. flask hold?

248. A flask holds 25 grams of water. The same flask holds 29 grams of hydrochloric acid. What is the specific gravity of the acid?

249. How many grams of chloroform, specific gravity 1.49, will a 50-cc. flask hold?

250. If a bottle holds 1826 grams of sulphuric acid, U. S. P., how many grams of water will it hold?

251. If 250 cc. of ether weigh 181.25 grams, what is the specific gravity of the ether?

252. What is the specific gravity of syrup when a fluidounce weighs 596.89 grains?

253. What is the specific gravity of alcohol when one liter weighs 820 Gm.?

254. What is the specific gravity of ammonia water when a bottle holds 50 grams of water or 48 grams of ammonia water?

255. A bottle weighing one apothecaries ounce, when filled with water, weighs 2 oz., 6 dr. and 48 grains; when filled with hydrochloric acid it weighs 3 ounces. What is the specific gravity of the acid?

256. What is the specific gravity of a liquid of which one pound will measure one pint?

257. A bottle holds three av. oz. of water and 1202.607 grains of another liquid. What is the specific gravity of the liquid?

258. An avoirdupois ounce of liquid measures 35 cc. Find its specific gravity.

259. The weight of five cubic centimeters of liquid is 100 grains. What is its specific gravity?

260. How many grams of bromine, sp. gr. 3.016, will be required to fill a bottle having a capacity of 11 fl. oz., 5 fl. dr. and 8 minims.

39. To Take the Specific Gravity of Liquids with a Plummet

The specific gravity of liquids may be found by weighing a solid in water, and again in the liquid of which the specific gravity is desired. If a solid body be weighed in water and also in air, the difference in the weights is the weight of a volume of water equal to the volume of the solid. If the same solid is weighed in any other liquid and the weight subtracted from the weight in air, the difference is the weight of a volume of liquid equal to the volume of the solid or to the weight of the same volume of water.

261. Example. *A piece of glass weighing 39 grams in air weighs 24 grams in water and 20.25 grams in glycerin. What is the specific gravity of the glycerin?*

$39 - 24 = 15$, the weight of water displaced.

$39 - 20.25 = 18.75$, the weight of glycerin displaced.

$18.75 \div 15 = 1.25$, the specific gravity of the glycerin.

Problems

262. A piece of glass weighs 39 grams in air, 24 grams in water, and 27.75 grams in ether. What is the specific gravity of the ether?

263. The same piece of glass weighs 16.65 grams in chloroform. What is the specific gravity of the chloroform?

264. If the same piece of glass weighs 27.6 grams less in sulphuric acid than in air, what is the specific gravity of the acid?

265. 56.75 grams of lead weigh 51.75 grams in water and 52.5 grams in alcohol. What is the specific gravity of the alcohol?

266. A piece of copper loses 14 grams when weighed in water, and 17.5 grams when weighed in glycerin. What is the specific gravity of the glycerin?

Note.—If a piece of glass be made of such a size that it will displace exactly 10 grams of water, then the loss of weight in any liquid divided by ten will give the specific gravity. If the specific gravity of glass is 2.600, then a piece weighing 26 grams will displace 10 grams of water, 12.4 grams of glycerin, or 7.16 grams of ether.

267. A piece of silver has a specific gravity of 10.25. How many grams must a piece weigh in air which will lose 10 grams when weighed in water?

268. How much will the same piece lose when weighed in glycerin?

269. Sulphuric acid has a specific gravity of 1.84. What must be the weight of a piece of lead having a specific gravity of 11.35 to displace 18.4 grams of the acid?

270. What must be the weight of a piece of copper, specific gravity 8.865, which will displace 125 grams of glycerin?

40. To Determine the Specific Gravity of Solids Insoluble in, but Heavier than, Water

Weigh the solid in air. Suspend in water by means of a silk thread, and weigh again. The difference in weight is the weight of the water displaced, and is equal in volume to the volume of the solid.

271. *Example.* A piece of native lead sulphide weighs in air 108.75 grams, in water 93.75 grams. What is its specific gravity?

$$108.75 - 93.75 = 15. \quad 108.75 \div 15 = 7.25 \text{ sp. gr.}$$

Problems

272. What is the specific gravity of a piece of lead weighing 35.412 grams in air and 32.292 grams in water?

273. A piece of copper weighs 34.008 grams in water, and 38.333 grams in air. What is the specific gravity?

274. What is the weight of water displaced by a piece of silver, specific gravity 10.25, which weighs 27.162 grams in air?

275. What is the weight of a piece of silver, specific gravity 10.25, which displaces 5 grams of water?

276. If one pound of lead, when weighed in water, loses 611 grains, what is its specific gravity?

277. If a bar of iron, when immersed in water, loses 13 per cent. of its weight, what is its specific gravity?

41. Solids Insoluble in, but Lighter than, Water

Weigh the substance in air and attach it to a sinker of known weight. Weigh in water and subtract the weight of both in water from the weight of both in air. The difference is the loss in weight of both in water. Find separately what the sinker loses in water and subtract this from what they both lose in water. The difference is the loss in weight of the substance in water.

278. Example. *A piece of lead weighs 11.35 grams in air and 10.35 grams in water. The lead is attached to a piece of wax weighing 2.16 grams in air, and their weight, taken together in water, is 10.26 grams. Find the specific gravity of the wax.*

$11.35 + 2.16 = 13.51$, the weight of both in air.

$13.51 - 10.26 = 3.25$, the loss in weight of both in water.

$11.35 - 10.35 = 1$, the loss in weight of the sinker in water.

$3.25 - 1 = 2.25$, the loss in weight of the wax in water.

$2.16 \div 2.25 = 0.96$, the sp. gr. of the wax.

A somewhat shorter method is the following:

Weigh the substance in air; weigh the sinker in water. Attach the substance to the sinker and weigh both in water.

Take the above example without the weight of the sinker in air.

$10.35 + 2.16 = 12.51$, the weight of the sinker in water plus the weight of the substance in air.

$12.51 - 10.26 = 2.25$, the loss in weight of the wax in water.

$2.16 \div 2.25 = 0.96$, the sp. gr. of the wax.

Problems

279. A piece of lead weighs 17.706 grams in air and 16.146 grams in water. A piece of spermaceti weighs 14.65 grams in air.

Spermaceti and lead in water weigh 15.296 grams. What is the specific gravity of the spermaceti?

280. Weight of wax in air.....	5	Gm.
“ “ sinker in air.....	20	Gm.
“ “ “ “ water.....	18	Gm.
“ “ “ and wax in water.....	17.8	Gm.

Find the specific gravity of the wax.

281. A cork weighs 9 grams in air. A sinker weighs 38 grams in water. The cork and sinker together weigh 3.25 grams in water. What is the specific gravity of the cork?

282. A piece of copper weighs 17.68 grams in air and 15.68 grams in water. A piece of cacao butter weighs 12.125 grams in air. The copper and cacao butter together weigh 15.305 grams in water. What is the specific gravity of the cacao butter?

283. A piece of paraffin weighs 13.80 grams. A piece of brass weighs 9 grams in water. The paraffin and brass together weigh 7.8 grams in water. What is the specific gravity of the paraffin?

284. What is the specific gravity of a piece of wood which weighs 18 grams? When attached to a piece of brass and suspended in water, both weigh 3.6 grams. The brass weighs 7 grams in water.

285. What is the specific gravity of a piece of wood which weighs in air 177.45 grains, if when attached to a piece of brass that weighs in water 68.25 grains the weight of the two in water is 35.7 grains?

286. A substance weighs 212.96 grains. A piece of brass weighs in water 117.8 grains. The weight of the substance and brass in water is 98.4 grains. What is the specific gravity of the substance?

42. To Find the Specific Gravity of Powders Insoluble in Water

Fill a specific gravity flask with water and weigh; empty the flask, introduce a weighed quantity of the powder, fill with water and weigh again. Add the weight of the powder to the weight of the flask filled with water, and from this amount subtract the weight of the flask containing the

powder and water. The difference is the weight of water displaced.

287. Example. *A bottle filled with water weighs 58 grams. The bottle containing 12 grams of sand and filled with water weighs 65.2 grams. Find the specific gravity of the sand.*

$$58 + 12 = 70.$$

$$70 - 65.2 = 4.8, \text{ the weight of water displaced.}$$

$$12 \div 4.8 = 2.5, \text{ the sp. gr. of the sand.}$$

Problems

288. Place 56.75 grams of lead shot in a specific gravity flask. The flask is then filled with water and is found to weigh 116.75 grams. The flask filled with water weighs 65 grams. What is the specific gravity of the shot?

289. A bottle filled with water weighs 24 grams. If 13.8 grams of granulated zinc be introduced into the bottle and the bottle filled with water, the combined weight will be 35.8 grams. What is the specific gravity of the zinc?

290. How many grams of water will be displaced by 1035 grams of zinc, specific gravity 6.9?

291. Weight of mercuric oxide.....38.5 Gm.

Weight of bottle filled with water.....35 Gm.

Weight of bottle containing mercuric
oxide, when filled with water.....70 Gm.

Find the specific gravity of the mercuric oxide.

292. When 33.488 grams of mercuric sulphate are placed in a bottle and the bottle filled with water, the combined weight is 68.79 grams. The weight of the bottle filled with water is 40.502 grams. What is the specific gravity of the mercuric sulphate?

293. How many grains of water will be displaced by an avoirdupois pound of mercury, specific gravity 13.56?

294. How many grams of mercury will an ounce bottle hold?

295. If 75 grams of granulated zinc having a specific gravity of 6.9 are placed in a flask filled with water, how many grams of water will be displaced?

296. A flask containing 57 grams of barium sulphate and filled with water weighs 109.5 grams. The flask filled with water weighs 65 grams. What is the specific gravity of the barium sulphate?

297. Mercuric sulphide has a specific gravity of 8.12. If 121.8 grams are put into a vial that holds exactly one fluidounce of water, how many grains of water will be displaced?

43. To Determine the Specific Gravity of Solids Soluble in Water

The method employed is the same as in taking the specific gravity of solids insoluble in water, except that, in place of water, some other liquid is used in which the substance is insoluble, as oil, alcohol, or turpentine. A correction is then made for the difference in the specific gravity of the liquid used and that of water, by multiplying the quotient obtained by the specific gravity of the liquid employed.

298. *Example. A crystal of potassium dichromate weighs 19.705 grams in air and 13.27 grams in deodorized alcohol, specific gravity 0.816. What is the specific gravity of the potassium dichromate?*

$19.705 - 13.27 = 6.435$, the loss of weight in alcohol.

$19.705 \div 6.435 = 3.062$, the specific gravity as compared with alcohol.

$3.062 \times 0.816 = 2.495$, the specific gravity as compared with water.

Problems

299. What is the specific gravity of copper sulphate, if a piece weighs 20.311 grams in air and 12.359 grams in turpentine having a specific gravity of 0.86?

300. A piece of borax weighs 23.62 grams in air and 12.323 grams in alcohol, specific gravity 0.816. What is the specific gravity of the borax?

301. A specific gravity flask filled with chloroform weighs 98.092 grams; 12 grams of salt are placed in the flask and the flask filled

with chloroform. The weight of the flask, salt and chloroform is 101.64 grams. The specific gravity of the chloroform is 1.49. What is the specific gravity of the salt?

302. The capacity of a specific gravity bottle is 50 grams of water or 43.686 grams of benzin. If 16 grams of potassium chlorate are added to the bottle and it is then filled with benzin, the contents weigh 53.244 grams. What is the specific gravity of the potassium chlorate?

303. A specific gravity bottle weighs 20.5 grams. When filled with water it weighed 70.5 grams; when filled with ether it weighed 56.75 grams; 25 grams of sucrose are placed in the bottle and the latter filled with ether, it then weighs 70.279 grams. What is the specific gravity of the sucrose?

304. Eleven grams of magnesium sulphate are put into a bottle that weighs 15 grams, and it is filled with turpentine. It then weighs 41.85 grams. The bottle filled with water weighs 40 grams, and when filled with turpentine it weighs 36.5 grams. What is the specific gravity of the magnesium sulphate?

305. A bottle filled with benzol weighs 34.8 grams. The specific gravity of the benzol is 0.879. Twenty grams of alum are put into the bottle and when filled with benzol it weighs 43.99 grams. What is the specific gravity of the alum?

SPECIFIC VOLUME

Specific volume is the volumetric ratio existing between the same weights of different bodies, as compared with the volume of the same weight of water. It is, therefore, the reverse of specific gravity. In pharmaceutical practice its use is confined to liquids. Specific volume may be found by dividing the volume of a given weight of the liquid by the volume of an equal weight of water.

44. To Find the Specific Volume of a Liquid

306. Example. *100 grains of glycerin measure 84 minims. 100 grains of water measure 105 minims. What is the specific volume of the glycerin?*

$84 \div 105 = 0.8$, the specific volume of the glycerin.

A given weight of liquid cannot be as accurately measured as a given volume of liquid can be weighed. Therefore, a better method is to find the specific gravity and divide 1 by the specific gravity. The specific gravity of glycerin is 1.25. $1 \div 1.25 = 0.80$, the specific volume of the glycerin.

Problems

307. What is the specific volume of stronger ammonia water, specific gravity 0.90?

308. Find the specific volume of nitric acid, specific gravity 1.420.

309. The specific gravity of bromine is 2.990. What is its specific volume?

310. What is the specific volume of chloroform if 1000 grains measure 1.473 fluidounces, and the same weight of water measures 2.195 fluidounces?

311. The specific gravity of oil of peppermint is .908. Find its specific volume?

312. The specific gravity of olive oil is 0.91. What is its specific volume?

313. What is the specific volume of a mixture of equal weights of olive oil and oil of peppermint?

314. If a kilogram of olive oil and two kilograms of oil of turpentine, sp. gr. 0.860, are mixed, what will be the specific volume of the mixture?

WEIGHT—VOLUME

Too much stress cannot be given to the importance of being able to change weight to volume and volume to weight, under all conditions.

When the specific gravity of a liquid differs from that of water an allowance must be made for difference in volume and weight.

45. To Find the Volume of a Given Weight of Any Liquid

315. Example. *How many fluidounces in 50 avoirdupois ounces of glycerin?*

50×0.96 (the equivalent in fluidounces of one avoirdupois ounce of water) = 48, which is the equivalent in fluidounces of 50 avoirdupois ounces. 48×0.8 (the specific volume of glycerin) = 38.4 fluidounces of glycerin; or we may divide by the specific gravity instead of multiplying by the specific volume.

(a) $50 \times 0.96 \times 0.8 = 38.4$, or

(b) $50 \times 0.96 \div 1.25 = 38.4$ fluidounces.

Problems

316. How many fluidounces in 75 apothecaries ounces of sulphuric acid, sp. gr. 1.84?

317. How many minims in 425 grains of sulphuric acid?

318. How many fluidounces in 150 av. oz. of nitric acid, sp. gr. 1.42?

319. How many minims in 156 grains of nitric acid?

320. How many cubic centimeters in 600 grams of hydrochloric acid, sp. gr. 1.16?

321. How many minims in 300 grains of hydrochloric acid?

322. How many fluidounces in 400 grams of olive oil, sp. gr. 0.915?

323. What is the volume in cubic centimeters of 50 grams of chloroform, specific gravity 1.49?

324. How many cubic centimeters in 50 grams of ether, specific gravity 0.725?

325. What is the cost of 8 fluidounces of glycerin, sp. gr. 1.25, when 10 pounds cost \$2.20?

326. If a 500-gram bottle of chloroform, sp. gr. 1.49, costs \$1.10, what is the cost of 1 fluidounce?

327. In the following formula, change the quantities of the liquids to cubic centimeters.

Pepsin	40	Gm.
Hydrochloric acid	12	"
Glycerin	406.25	"
Water	660	"

328. How many fluidounces will be formed by mixing a pound of chloroform with a pound of ether, no allowance being made for contraction?

329. How many cubic centimeters in 10 avoirdupois pounds of mercury, specific gravity 13.5?

330. How many fluidounces in one avoirdupois pound of tincture of ferric chloride, sp. gr. 1.005?

331. What is the combined volume of an avoirdupois pound of syrup, sp. gr. 1.313, and an avoirdupois pound of glycerin, sp. gr. 1.25?

332. How many cubic centimeters in 100 grams of ether and 50 grams of alcohol?

333. What is the value of five avoirdupois pounds of spirit of nitrous ether, sp. gr. 0.82, at 40 cents a pint?

46. To Find the Weight of a Given Volume of Any Liquid

334. **Example.** *How many apothecaries ounces in 100 fl. oz. of chloroform?*

$100 \times 0.95 = 95$ apothecaries ounces. 95×1.49 , the sp. gr. of chloroform, = 141.55 apoth. oz. of chloroform.

Problems

335. How many avoirdupois pounds in one pint of mercury, sp. gr. 13.535?
336. How many grams in a quart of ether, sp. gr. 0.716?
337. How many grains in 425 minims of either?
338. What is the weight in grams of 650 cc. of alcohol, sp. gr. 0.82?
339. How many grams in 25 liters of syrup, sp. gr. 1.300?
340. If the specific gravity of acetone is 0.79, how many grams are there in two fluidounces?
341. What will be the cost of four pints of glycerin, sp. gr. 1.25, at 18 cents per pound?
342. What will 390 minims of glycerin weigh?
343. Which is heavier, and how much, one fluidounce of mercury, sp. gr. 13.5, or one pint of oil of turpentine, sp. gr. 0.86?
344. If one pint of syrup, sp. gr. 1.313, be mixed with 500 cc. of glycerin, how many apothecaries ounces will the mixture weigh?
345. What will one pint of chloroform cost if one pound costs 60 cents?
346. What will one pint of ether cost if one pound costs 70 cents?
347. What will 5 gallons of glycerin cost at 20 cents a pound?
348. If 5 pints of sulphuric acid, sp. gr. 1.84, cost \$1.15, what is the cost of one pound?
349. If glycerin costs 22 cents a pound, what is the cost of a gallon?

47. To Find the Volume of Pure Substance in a Given
Weight of Liquid when the Per Cent. by Weight
Is Given

350. *Example.* A solution contains 10 per cent. by weight of glycerin. How many fluidounces of glycerin in 40 apothecaries ounces of the solution?

$$40 \times 0.10 \times 1.05 \div 1.25 = 3.36 \text{ fl. oz. of glycerin.}$$

Problems

351. How many fluidounces of absolute alcohol, sp. gr. 0.79, in 150 apothecaries ounces of dilute alcohol containing 41.5 per cent. of alcohol?

352. How many cubic centimeters of oil of anise in 750 grams of spirit of anise, if the spirit contains 13 per cent. of the oil, having a sp. gr. of 0.98?

353. How many cubic centimeters of ether, and of alcohol, in 810 grams of spirit of ether, which contains 30 per cent. of ether and 70 per cent. of alcohol?

354. If white wine contains 12 per cent. by weight of alcohol, sp. gr. 0.79, how many fluidounces of alcohol are there in two quarts of wine, the specific gravity of the wine being the same as that of water?

48. To Find the Weight of Pure Substance in a Given Volume of Liquid when the Per Cent. by Volume Is Given

355. *Example. How many apothecaries ounces of absolute alcohol in 15 fluidounces of alcohol containing 60 per cent. by volume of absolute alcohol?*

$15 \times 0.60 = 9$, the volume of absolute alcohol.

9×0.95 (to change from fl. oz. to apothecaries) = 8.55.

$8.55 \times 0.797 = 6.814$ apothecaries ounces of absolute alcohol.

Problems

356. Spirit of chloroform contains 6 cc. of chloroform in 100 cc. of the spirit. How many grams of chloroform, sp. gr. 1.49, in 7500 cc. of the spirit?

357. Spirit of cinnamon contains 10 per cent. by volume of the oil of cinnamon, which has a specific gravity of 1.06. How many grams of the oil are required to make two and a half liters of the spirit?

358. Liniment of ammonia contains:

Ammonia water.....	sp. gr. 0.96	25% by volume
Oleic acid.....	sp. gr. 0.895	1% “ “
Sesame oil.....	sp. gr. 0.92	74% “ “

How many apothecaries ounces of each will be required to make two pints of the above liniment?

359. Solution of zinc chloride has a sp. gr. of 1.548 and contains 50 per cent. of zinc chloride. How many grams of zinc chloride in 7.5 liters?

360. How many grams of glycerin, sp. gr. 1.25, in 4 liters of syrup of wild cherry which contains 5 per cent. by volume of glycerin?

361. How many pounds of chloroform, sp. gr. 1.49, in a gallon of chloroform liniment which contains 30 per cent. by volume of chloroform?

362. How many grams of chloroform in one liter of spirit of chloroform, if the spirit contains 6 per cent. by volume of chloroform?

363. How many grams of glycerin in one liter of fluid extract of cinchona which contains 10 per cent. by volume of glycerin?

364. Aromatic spirit of ammonia contains 9 per cent. of ammonia water, sp. gr. 0.96; 70 per cent. of alcohol, sp. gr. 0.81; 1 per cent. of oil of lemon, sp. gr. 0.85. How many ounces or grains of each in one pint of the spirit?

365. Compound tincture of lavender contains 8 per cent. of oil of lavender, sp. gr. 0.88, and 2 per cent. of oil of rosemary, sp. gr. 0.900. How many grains of each in a gallon of the tincture?

49. To Find the Per Cent. by Volume when the Per Cent. by Weight Is Given

366. *Example.* A mixture of alcohol and water, having a specific gravity of 0.9, contains 58 per cent. by weight of alcohol. What is the per cent. by volume?

A unit weight of the solution contains 0.58 of a unit weight of absolute alcohol. This 0.58 of a unit weight

divided by the specific gravity of absolute alcohol equals the volume of absolute alcohol which a unit weight of the solution contains, $\frac{0.58}{0.797} = 0.7277$. The volume of a unit weight of the solution is 1 divided by its specific gravity, $\frac{1}{0.9} = 1.111$. The volume of absolute alcohol divided by the volume of the solution equals the per cent. by volume. $0.7277 \div 1.111 = 0.6549$, the per cent. by volume.

$$\text{Thus, } \frac{0.58}{0.797} \div \frac{1}{0.9} = 0.6549, \text{ or } \frac{0.58}{0.797} \times 0.09 = 0.6549.$$

Problems

367. Alcohol having a specific gravity of 0.9135 contains 52 per cent. by weight of absolute alcohol. What is the per cent. by volume?

368. What is the per cent. by volume of absolute alcohol in a solution having a specific gravity of 0.9623 and containing 27 per cent. by weight of absolute alcohol?

369. Alcohol containing 38 per cent. by weight of absolute alcohol has a specific gravity of 0.943. What is the per cent. by volume?

370. What is the per cent. by volume of commercial alcohol, sp. gr. 0.82, in a spirit containing 54.95 per cent. by weight of commercial alcohol and having a sp. gr. of 0.9184?

371. What is the per cent. by volume of glycerin in a mixture having a sp. gr. of 1.143 and containing 55 per cent. by weight of glycerin?

372. If spirit of ether has a sp. gr. of 0.7972 and contains 30 per cent. by weight of ether, sp. gr. 0.725, what is the per cent. by volume?

373. If the specific gravity of tincture of ferric chloride is approximately that of water, and 1000 cc. of it contains 455 grams of solution of ferric chloride, sp. gr. 1.300, what per cent. by volume of the solution does the tincture contain?

50. To Find the Per Cent. by Weight when the Per Cent. by Volume Is Given

374. Example. *A solution of alcohol in water having a specific gravity of 0.9 contains 66 per cent. by volume of absolute alcohol. What is the per cent. by weight?*

A unit volume of the solution contains 0.66 of a unit volume of absolute alcohol. 0.66 multiplied by the specific gravity of absolute alcohol equals the weight of absolute alcohol in a unit volume of the solution: $0.66 \times 0.797 = 0.526$. The weight of a unit volume of the solution is 1 multiplied by its specific gravity, $1 \times 0.9 = 0.9$. The weight of absolute alcohol divided by the weight of the solution equals the per cent. by weight: $0.526 \div 0.9 = 0.584$.

$0.66 \times 0.797 \div 0.9 = 0.584$ or 58.4 per cent. by weight.

Problems

375. Dilute alcohol having a specific gravity of 0.9264 contains 54 per cent. by volume of absolute alcohol. What per cent. by weight does it contain?

376. What is the per cent. by weight of absolute alcohol in dilute alcohol having a specific gravity of 0.8557 and containing 83 per cent. by volume of absolute alcohol?

377. A dilute alcohol containing 11 per cent. by volume of absolute alcohol has a specific gravity of 0.9857. What per cent. by weight of absolute alcohol does it contain?

378. Tincture of ferric chloride has a specific gravity of 1.000 and contains 35 per cent. by volume of the solution of ferric chloride, which has a specific gravity of 1.315. What is the per cent. by weight?

379. White wine having the same specific gravity as water contains 13 per cent. by volume of absolute alcohol. What per cent. by weight of absolute alcohol does it contain?

380. One liter of aromatic sulphuric acid, sp. gr. 0.933, contains 109 cc. of sulphuric acid, sp. gr. 1.83. What per cent. by weight of the acid does it contain?

51. Ratio

Ratio is an expression of the relation of one term to another, that is, the amount of one term is greater than another, and may be expressed thus: $12/4$ or $12:4$, and is read 12 is to 4.

The ratio of two numbers is the quotient obtained by dividing one term by another. The ratio of $12:3$ is 4.

The terms of a ratio may be considered as dividend and divisor, both terms of which may be multiplied or divided by the same number without changing their value.

Thus we may multiply both terms of the ratio $12:4$ by 4, and we have $48:16$, or divide both terms by 4 and we have $3:1$ and in each case their ratio is 3:1.

The terms of a ratio taken together form a couplet.

Ratio can exist only between numbers of the same unit value; as, the ratio of per cent. to per cent. or weight to weight, but not weight to per cent.

52. Proportion

Proportion is the expression of equality between ratios. It is written thus: $12:6::24:12$, and is read 12 is to 6 as 24 is to 12.

The quotients of each couplet are equal, $12:6=2$, $24:12=2$.

The first and fourth terms are called the extremes. The second and third terms are called the means.

The product of the extremes is equal to the product of the means, $24 \times 6 = 144$, $12 \times 12 = 144$. It therefore follows that if three terms of a proportion are given the fourth may be found.

Either extreme may be found by dividing the product of the means by the other extreme.

Either mean may be found by dividing the product of the extremes by the other mean.

381. Example. *How many grams of 10 per cent. sulphuric acid can be made from 40 grams of 94 per cent. acid?*

Here we have the two terms of per cent. and one of the weight given, to find the other. By multiplying the means, 94 by 40, and dividing by the extreme, 10, gives us the other extreme.

Thus: $10 : 94 :: 40 : 376$, which is the amount of 10 per cent. acid that can be formed from 40 grams of 94 per cent.

382. Example. Had the problem required to find the amount of 94 per cent. acid required to make 376 grams of 10 per cent., we would have: $19 : 94 :: x : 376$.

383. Example. Had it been required to find the strength of 40 grams, which, when diluted to 376 grams, would make a 10 per cent. acid, we would have: $10 : x :: 40 : 376$.

384. Example. If the problem had been to find the strength of acid that could be made by diluting 40 gm. of 94 per cent. acid to 376 gm., we would have: $x : 94 :: 40 : 376$.

In practice it is customary to let the unknown term, represented by x , occupy the fourth place. The preceding problems then take the following form:

$$\begin{aligned} 10 : 94 :: 40 : x &= 376 \\ 94 : 10 :: 376 : x &= 40 \\ 40 : 376 :: 10 : x &= 94 \\ 376 : 40 :: 94 : x &= 10 \end{aligned}$$

When stating a proportion we are less apt to make a mistake if we place x in the fourth place and the number which is of the same denomination as the required number in the third place. Then if the answer is to be larger than the third term, place the larger of the remaining terms in the second place, if less the smaller of the remaining terms in the second place, and the remaining term in the first place.

Use proportion in solving the following problems.

Problems

385. How many grams of 28 per cent. ammonia water will be required to make 500 grams of 10 per cent. ammonia water?

386. If 20 pounds of sucrose cost \$1.32, what will 75 pounds cost?

387. If a pound of citric acid costs 65 cents, what will 7 ounces cost?

388. When citric acid costs 65 cents a pound, how many ounces can be bought for \$1.55?

389. If 12 fluidounces of glycerin weigh 15.6 av. oz., what will one gallon weigh?

390. If 6 fluidounces of mercury weigh 81.12 av. oz., what will a pint weigh?

391. If a 12-ounce bottle holds 162.24 av. oz. of mercury, how large a bottle will be required to hold 27 avoirdupois ounces?

392. If 165 grams of mercury measure 65 cc., what will a kilogram measure?

393. If 250 cc. of glycerin weigh 312.5 grams, what will 175 cc. weigh?

394. If a 5-pound can of glycerin costs \$1.55, what will 62 pounds cost?

395. When glycerin costs 28 cents a pound, what will be the cost of a gallon if 20 fluidounces weigh 27 avoirdupois ounces?

PERCENTAGE SOLUTIONS

It is frequently necessary for a pharmacist to prepare solutions of a given percentage strength. In this connection the expressions *per cent.* and *percentage* do not always have identical meanings, but vary according to circumstances. In pharmaceutical practice there are three types of percentage solutions: (1) weight in weight (w/w), (2) weight in volume (w/v), and (3) volume in volume (v/v).

Weight in weight (w/w) percentage solutions are those which contain a given weight of an active ingredient in 100 parts by weight of the finished solution. Thus a 20 per cent. (w/w) solution of potassium iodide in water is one which contains 6 grams of the salt in 30 grams (*not cubic centimeters*) of the finished solution, or 90.9 grains of potassium iodide in 454.6 grains (*not one fluidounce*) of the finished solution. Thirty grams of a 20 per cent (w/w) solution of potassium iodide in water will not measure 30 cubic centimeters, and 454.6 grains of it will not measure one fluidounce. The reason that it will not is that potassium iodide has a specific gravity of more than 3, and each gram of it when dissolved in water will occupy a volume of about 0.3 cubic centimeter. A 20 per cent. (w/w) solution of potassium iodide will have a specific gravity of approximately 1.18, and 30 grams of a solution of this strength will measure about 25.5 cubic centimeters. Since a specified volume of a percentage solution is usually ordered, a weight in weight (w/w) percentage solution is dispensed only when definitely indicated.

Weight in volume (w/v) percentage solutions are those which contain a given weight of an active ingredient in 100 parts by volume of the finished solution. Using the same example as in the preceding explanation, a 20 per cent. weight in volume (w/v) solution of potassium iodide in water is one which contains 6 grams of the salt in 30 cubic

centimeters (*not grams*) of the finished solution, or 90.9 grains of potassium iodide in one fluidounce (*not 454.6 grains*) of the finished solution. This solution will contain 0.2 gram of potassium iodide per cubic centimeter. However, on a weight in weight (w/w) percentage basis it will contain approximately 17.5 per cent. of potassium iodide. Assuming that each gram of potassium iodide when dissolved in water occupies a volume of 0.3 cubic centimeter, it becomes apparent that 28.2 cubic centimeters of water must be added to 6 grams of the salt to produce a volume of 30 cubic centimeters of solution. This 30 cubic centimeters of solution will weigh 34.2 grams, of which 6 grams are potassium iodide. The (w/w) percentage strength of the solution may then be calculated as follows: $(6 \div 34.2) \times 100 = 17.54\%$. This example shows the difference between a 20 per cent. weight in weight (w/w) and a 20 per cent. weight in volume (w/v) solution of potassium iodide in water. Whenever a percentage solution of any salt in water is prepared on a weight in volume (w/v) basis, the actual, or weight in weight (w/w), percentage will be less than the percentage used to express the weight in volume (w/v) strength. In general, as the weight in volume (w/v) percentage increases, the difference between it and the actual or weight in weight (w/w) percentage will become greater. An illustration will explain this. Potassium iodide is soluble to the extent of one gram in 0.7 cubic centimeter of water. A saturated solution accordingly contains 58.82 per cent. of potassium iodide on a weight in weight (w/w) basis. (See Section No. 56.) What will be the corresponding weight in volume (w/v) percentage strength? If 100 grams of potassium iodide are dissolved in 70 cubic centimeters of water, 100 cubic centimeters of a saturated solution will result. This solution contains 100 grams of salt in 100 cubic centimeters of solution, and will be a 100 per cent weight in volume (w/v) solution. If we were dealing with a saturated solution of sodium iodide we would have to refer to it on this basis as a 118% solution.

Volume in volume (v/v) percentage solutions are those which contain a given volume of active ingredient in 100 parts by volume of the finished solution. Per cent., or percentage, (v/v) is an expression of the number of cubic centimeters of active ingredient in 100 cc. of solution. Thus, a 10 per cent. (v/v) solution of glycerin in water is one that contains 3 cubic centimeters of glycerin in 30 cubic centimeters of the finished solution, or 48 minims of glycerin in one fluidounce of the finished solution.

There has always been wide divergence of opinion among pharmacists as to how percentage solutions should be prepared when there is no specification as to which of the above types should be dispensed. In order to clarify this situation, the U. S. P. XI includes a monograph on percentage solutions. Included in this monograph is the following statement: "When the expression, "per cent.," is used in prescriptions without qualification, it is to be interpreted to mean: for solutions of solids in liquids, per cent., weight in volume; for solutions of liquids in liquids, per cent., volume in volume; and for solutions of gases in liquids, per cent., weight in volume. For example, a 1 per cent. solution is prepared by dissolving 1 gram of a solid or 1 cubic centimeter of a liquid in sufficient of the solvent to make 100 cubic centimeters of the solution. A solution of the same strength may be prepared by apothecaries weight and measure by dissolving 4.5 grains (more accurately, 4.5457 grains, at 25° C.) of a solid or 4.8 minims of a liquid in sufficient of the solvent to make 1 fluidounce of the solution."

**53. To Find the Amount of Substance Required to
Make a Given Quantity of a (w/v) Solution
when the Per Cent. (w/v) Is Given**

396. Example. *How many grains of boric acid will be required to prepare two fluidounces of a 5 per cent. solution of boric acid in water?*

Two fluidounces of water weigh 909.2 grains. Five per

cent. of 909.2 is 45.46 grains. 45.46 grains of boric acid are to be dissolved in sufficient water to make two fluidounces of finished solution.

Note.—If the solvent directed were alcohol or glycerin the amount of boric acid would be the same.

Problems

397. How many grains of mercuric chloride are required to make one pint of a 0.1 per cent. aqueous solution?

R

Carbolic acid solution, 4%.....fl ij

Boric acid solution, 5%.....fl ij

Mix.

398. How many grains of boric acid and carbolic acid are required in the above prescription?

399. How many grains of boric acid are required to make 4 fluidounces of a 5 per cent. solution in glycerin?

400. How many grains of silver nitrate must be taken to make one fluidounce of a 0.02 per cent. solution in water?

401. How many grains of mercuric chloride will be required to make 8 fluidounces of a 0.25 per cent. solution?

402. How would you prepare one fluidounce of a one per cent. solution of cocaine hydrochloride in water?

403. How would you prepare 2 fluidounces of a 5 per cent. solution of liquefied phenol in glycerin?

404. R

Menthol, 1%

Oil of Lavender, 5%.

Alcohol, q. s. ad fl. $\frac{3}{4}$ j

How many grains of menthol and how many minims of oil of lavender should be used?

405. How many grains of phenol will be required to make one-half fluidounce of carbolated oil containing 5 per cent. of phenol?

406. How many grams of picric acid will be required to prepare 240 cubic centimeters of a 5 per cent. solution in alcohol?

407. If 10 grains of cocaine hydrochloride are dissolved in a sufficient amount of water to make 1 fluidounce, what is the percentage strength of the solution (w/v)?

408. If 18.2 grains of silver nitrate are dissolved in a sufficient quantity of water to make one fluidounce, what is the percentage strength (w/v) of the solution?

409. How many grams of mild silver-protein should be used to prepare 120 cubic centimeters of a 25 per cent. solution?

410. How many cubic centimeters of methyl salicylate must be used to prepare 180 cubic centimeters of a 6 per cent. solution in alcohol?

54. To Find the Amount of Substance Required to Make a Given Quantity of a Solution when the Concentration Is Expressed in Parts of Solute per Thousand Parts of Solvent

Very frequently instead of expressing the strength of a very dilute solution in terms of per cent., a solution containing a given number of parts of solute per thousand parts of solvent will be ordered.

411. Example.

R Potassii permanganatis, (1:5000), fl. ℥ viij
Sig. Use as injection as directed.

In the above prescription, 1/5000 of the finished solution must be potassium permanganate. The strength of the solution will be 0.02 per cent. The quantity of potassium permanganate required may then be calculated as follows: The weight of one fluidounce of water is 454.6 grains. Eight fluidounces will weigh 3636.8 grains. 0.02 per cent. of this is 0.73 grain of potassium permanganate which must be dissolved in sufficient water to make eight fluidounces of solution.

The above problem may also be solved by proportion as follows:

$$5000 : 1 :: 3636.8 : x$$

$$x = 0.728, \text{ grains of } \text{KMnO}_4$$

Problems

412. How many grains of mercuric chloride must be used to make a pint of a 1:2000 solution?

413. How many mgms of potassium permanganate must be used to prepare one liter of a 1:10000 solution?

414. How many grains of thymol must be added to one gallon of a solution so that the concentration of the thymol will be 1 part in 1000?

415. How many tablets, each containing 0.5 Gm. of mercuric chloride, should be used to prepare one quart of a 1:1000 solution?

416. If one small tablet of mercuric chloride containing 0.125 Gm. of mercuric chloride is dissolved in sufficient water to make 500 cc., what is the concentration of the solution expressed in parts per thousand?

417. How many grains of silver nitrate should be used to prepare one fluidounce of a 5:1000 solution?

55. To Prepare Solutions of a Given Percentage (w/w) Strength

If a definite weight of a (w/w) percentage solution is wanted the calculations involved are simple.

418. Example. *How many grams of lithium bromide are required to make 120 grams of a 20 per cent. (w/w) aqueous solution?*

$120 \times 0.20 = 24$ grams of lithium bromide which must be dissolved in 96 grams of water to make 120 grams of a 20 per cent. (w/w) solution.

As has already been pointed out, a solution prepared in this way will not measure 120 cc.

More frequently a definite volume will be required, and

for this, either one of two methods of calculation may be conveniently employed.

419. Example. *How many grams of lithium bromide must be used to make 120 cc. of a 20 per cent (w/w) aqueous solution? The specific gravity of a lithium bromide solution of this strength is 1.15.*

$120 \times 1.15 \times 0.20 = 27.6$ grams of the salt, which, when dissolved in a sufficient quantity of water to make 120 cc., will produce a 20 per cent. (w/w) solution.

When the specific gravity of a solution of a given percentage (w/w) strength is not available, it is possible to calculate readily how much of a salt will have to be added to a given volume of solvent to make a solution of that (w/w) percentage strength.

420. Example. *How many grams of lithium bromide must be added to 120 cc. of water to make a 20 per cent. (w/w) solution?*

In the finished solution the 120 cc. of water will account for 80 per cent. of its weight, while 20 per cent. will be lithium bromide. Since 120 grams of water must be 80 per cent. of the finished solution, 1 per cent. is $\frac{1}{80}$ of 120, or 1.5 grams. If 1.5 grams equal 1 per cent, then 20 per cent. equal 20 times 1.5 grams, or 30 grams, the quantity of lithium bromide to be dissolved in 120 cc. of water. Or, $100\% - 20\% = 80\%$. $\therefore 80 : 20 :: 120 : x, x = 30$ grams.

Problems

421. How many grams of zinc sulphate must be dissolved in 470 grams of water to make a 6 per cent. (w/w) solution?

422. How many grams of tannic acid must be dissolved in 320 cc. of glycerin, sp. gr. 1.25, to make a 20 per cent. (w/w) solution? What will be the weight of the solution?

423. How many grams of sodium iodide must be dissolved in one fluidounce of water to make a 25 per cent. (w/w) solution?

424. How many grains of boric acid must be dissolved in four fluidounces of water to make a 5 per cent. (w/w) solution?

425. The specific gravity of a 10 per cent. (w/w) solution of sodium iodide is 1.08. How would you prepare three fluidounces of a 10 per cent. (w/w) solution?

426. How many grams of potassium iodide must be dissolved in 250 cc. of water to make a 20 per cent. (w/w) solution?

427. How many grains of potassium bromide will be required to make a 15 per cent. (w/w) solution when dissolved in 3 fluidounces of water?

428. If the specific gravity of a 15 per cent. (w/w) solution is given as 1.12, how many grams of potassium bromide would you dissolve in a sufficient quantity of water to make 90 cc. of a solution of that strength?

429. What weight of sucrose must be dissolved in a pint of water to make a 65 per cent. (w/w) syrup?

430. The specific gravity of a 64.7 per cent. (w/w) solution of sucrose in water is approximately 1.313. How many grams of water and how many grams of sucrose will be required to make 1500 cc. of a 64.7 per cent. (w/w) aqueous solution? What will be the weight in volume (w/v) percentage strength of such a solution?

56. To Determine the (w/w) Percentage Strength of Saturated Solutions when the Solubilities of Solutes Are Given

In the U. S. P. XI, solubilities of official substances when known are stated in terms of the number of cubic centimeters of solvent required to dissolve one gram of substance at 25° C. These solubility statements are not intended as absolute physical constants, but rather as close approximations thereto for the information of pharmacists in the preparation and dispensing of solutions.

431. Example. *One gram of boric acid is soluble in 18 cc. of water at 25° C. What is the percentage strength (w/w) of a saturated solution?*

If one gram of boric acid is dissolved in 18 cc. of water, the resulting solution will weigh approximately 19 grams. What per cent. is 1 gram of 19 grams? $(1 \div 19) \times 100 = 5.26$ per cent. (w/w) strength of a saturated solution of boric acid in water.

Problems

432. What is the percentage strength (w/w) of a saturated solution of strychnine if 1 gram is soluble in 6420 cc. of water?

433. One gram of potassium iodide is soluble in 0.7 cc. of water. What is the percentage strength (w/w) of a saturated solution?

434. One gram of boric acid is soluble in 18 cc. of alcohol. What is the percentage strength (w/w) of a saturated alcoholic solution?

435. What is the percentage strength (w/w) of a saturated solution of camphor if 1 gram is soluble in 800 cc. of water?

436. If potassium chlorate is soluble in 16.5 parts of water, how many grams will dissolve in 125 cc. of water, and what per cent. (w/w) of the chlorate will the solution contain?

437. One gram of chloral hydrate is soluble in 0.25 cc. of water. What is the (w/w) percentage strength of a saturated solution?

438. One gram of atropine is soluble in 455 cc. of water. What is the (w/w) percentage strength of a saturated solution?

439. One gram of atropine is soluble in 27 cc. of glycerin. What is the (w/w) percentage strength of a saturated solution?

57. To Calculate the Quantity of Solvent and Solute Required to Make a Given Volume of a Saturated Solution

The National Formulary VI includes directions for the preparation of a saturated solution of potassium iodide. It may occasionally be necessary to prepare saturated solutions of other substances. The calculations involved will vary with the solubility of the substance.

(1) For substances which are soluble in not less than 10 parts of the solvent.

Ascertain the solubility of the substance by reference to the U. S. P. XI or the N. F. VI. Calculate the (w/w) percentage strength of a saturated solution as directed in Example 431, page 62. Now calculate how much of the substance must be added to the volume of solvent corresponding to the volume of solution wanted. Either discard or dispense the excess amount of solution formed in this way.

440. Example. *How may one fluidounce of a saturated solution of potassium chlorate be prepared? One gram of potassium chlorate is soluble in 16.5 parts of water at 25° C.*

$\frac{1}{17.5} \times 100 = 5.7$ per cent. (w/w), the strength of a saturated solution of potassium chlorate. The problem now becomes, how many grains of potassium chlorate must be added to one fluidounce of water to make a 5.7 per cent. (w/w) solution?

$$94.3\% : 5.7\% :: 454.6 : x$$

$$x = 29 + \text{grains of potassium chlorate}$$

dissolved in one fluidounce of water will make a saturated solution at 25° C. The solution will measure slightly more than one fluidounce.

(2) For substances which are soluble in less than 10 parts of solvent.

For substances which are very soluble or which are unusually expensive, the preceding method of calculation would be unsuitable from the standpoint of economy.

If the approximate specific gravity of the saturated solution which is to be prepared is known, the calculation of the amount of solute to use in order to prepare a given volume of solution is simple.

441. Example. *How many grams of potassium iodide are required to prepare 100 cc. of a saturated aqueous solution?*

The specific gravity of a saturated solution is approximately 1.7.

One gram of potassium iodide is soluble in 0.7 cc. of water at 25° C.

$\frac{1}{1.7} \times 100 = 58.8$ per cent. (w/w) strength of a saturated aqueous solution of potassium iodide. Since 100 cc. of solution is to be prepared containing 58.8 per cent. (w/w) of potassium iodide, the calculation of the quantity required will be as follows:

$100 \times 1.7 \times 0.588 = 99.96$ Gm. of potassium iodide, which, if dissolved in a sufficient quantity of water to make 100 cc., will produce a saturated solution. (Compare calculations with the formula for Liquor Potassii Iodidi, N. F. VI.)

If the specific gravity of the saturated solution is not available, another method may be resorted to. Using the same example as above, but assuming that the specific gravity is not known for a saturated solution of potassium iodide, an amount of water somewhat less than the volume of solution wanted might be saturated with the salt.

Thus, 50 cc. of water could first be saturated with potassium iodide by dissolving 71.43 Gm. of potassium iodide in it. It would be noted that the volume increased to approximately 73 cc., or that each gram of potassium iodide dissolved in water occupies a volume of approximately 0.32 cc. From this observation it could readily be calculated that if an additional 20 cc. of water were saturated by dissolving 28.57 Gm. of potassium iodide in it, the volume would be about 28.6 cc. This, obviously, would make nearly 4 cc. more than the desired volume. The next calculation would probably be on the basis of saturating 18 cc. of water by dissolving 25.7 Gm. of potassium iodide in it. The calculated volume of this solution would be found to be 25 cc., which is the volume, that, if added to the 73 cc. already prepared would produce approximately 100 cc. of saturated solution.

58. To Make a Solution of Given Strength when the Amount of the Substance Is Given

442. Example. *How much 0.85 per cent. solution can be made from 17 grams of sodium chloride?*

As each 100 cc. of the solution must contain 0.85 gram, there must be as many times 100 as 0.85 is contained in 17.

$$\frac{17}{0.85} \times 100 = 2000$$

Problems

443. How many grains of water must be added to 15 grains of cocaine hydrochloride to make a 4 per cent. (w/w) solution?

444. How many grains of water will be required to make a 5 per cent. (w/w) solution from 60 grains of zinc sulphate?

445. How many grams of 5 per cent. sodium hydroxide solution can be made from 32 grams of sodium hydroxide?

446. How many apothecaries ounces of 5 per cent. sodium hydroxide solution can be made from 450 grains of sodium hydroxide containing five per cent. of impurities?

447. How many cubic centimeters of physiological salt solution, 8.5 grams to 1000 cc., can be made from 340 grams of salt?

448. How many avoirdupois ounces of Lugol's solution, containing 5 per cent. of iodine, can be made from 250 grains of iodine?

449. How many fluidounces of 9.6 per cent. (w/w) sulphuric acid can be made from three avoirdupois ounces of 95 per cent. acid?

450. How many cubic centimeters of syrup, containing 85 per cent. weight in volume of sucrose, can be prepared from 5 kilograms of sucrose?

451. How many grams of 4 per cent. oleate of cocaine can be prepared from 1.5 grams of cocaine?

452. How many grams of 20 per cent. oleate of mercury can be prepared from 65 grams of mercuric oxide?

453. In how many cubic centimeters of water must 60 grams of salt be dissolved in to make a 4 per cent. (w/w) solution?

454. Potassium chlorate is soluble in 16.5 parts of water. How many grains of a saturated solution can be prepared from 450 grains?

455. How many grams of alcohol will be required to dissolve 50 grams of salicylic acid, if one Gm. is soluble in 2.7 cc. of alcohol? What is the per cent. (w/w) strength of the solution?

456. If 1 Gm. of acetanilid is soluble in 3.4 cc. of alcohol, what is the per cent. strength, and how many grams of saturated solution can be prepared from 65 grams of acetanilid?

59. To Find the Strength of a Solution when the Quantity of the Substance and Solution Are Given

457. *Example. What is the strength of cocaine hydrochloride in a solution made by dissolving 24 grains in 576 grains of water?*

Where the quantity of the solvent is given, the amount of the solvent and substance must be added to obtain the total quantity of the solution before the percentage can be obtained.

Thus: $576 + 24 = 600$, the number of grains of solution.
 $24 \div 600 = .04$, the per cent. of cocaine in the solution.

Or, by proportion, if 600 grains of the solution contain 24 grains of cocaine, 100 grains of the same solution will contain x grains of cocaine.

Thus: $600 : 24 :: 100 : x$, $x = 4$ per cent. of cocaine.

Problems

458. If 16 ounces of solution contain 2 ounces of a salt, what is the strength of the solution?

459. If 4 drams of potassium bromide are dissolved in water to make 16 apothecaries ounces, what is the strength of the solution?

460. Four hundred and fifty grams of solution of zinc chloride contain 216 grams of zinc chloride. What is the strength of the solution?

461. Fifty-six grams of 95 per cent. sodium hydroxide are dissolved in 944 grams of water. What is the strength of the solution?

462. Potassium iodide is soluble in approximately three-fourths of its weight of water. What is the strength of the saturated solution?

463. What is the strength of a solution of sodium sulphate if 420 grams of the solution contain 150 grams of the salt?

464. A solution of ferric chloride has a sp. gr. of 1.31 and contains 187 grams of iron in 1145 cc. of solution. What per cent. of iron does it contain?

60. Stock Solutions

For convenience in dispensing pharmacists often keep on hand strong solutions from which weaker solutions can quickly be dispensed.

465. Example. *A prescription calls for a solution containing 3 grains of mercuric chloride in one pint. If the pharmacist has a stock solution containing 20 grains in an ounce, which is 1 grain in 24 minims, he can take 72 minims of the solution and dilute it to 1 pint and he will have a solution containing 3 grains in a pint.*

Stock solutions can be made of any convenient strength. A solution of the strength of 1 in 10, or some multiple of 10, is convenient where the amounts are divisible by 10. A solution 1 in 12, or some multiple of 12, is convenient where a fraction of a grain is desired, since 12 is divisible by 2, 3, 4, and 6. By the use of such solutions fractional parts of a grain can be more accurately obtained than by weighing with an ordinary prescription balance.

Problems

466. How many minims of a 50 per cent. solution of zinc chloride must be used to make 8 fluidounces, of the strength of 1:500?

467. How many minims of a stock solution of mercuric chloride,

1 in 32, must be used to make a pint of solution containing one grain in 3000?

468. What should be the strength of a stock solution of mercuric chloride, one fluid dram of which diluted to a half pint will make a solution the strength of which is 1:2000?

469. How many minims of the above stock solution must be used to make a pint of an aqueous solution containing 1:1500?

470. How many grams of mercuric chloride should 250 cc. of solution contain, so that 20 cc. diluted to a liter will make a solution containing 1:3000?

471. How many cc. of the N. F. VI. Solution of Aluminum Acetate must be used to take one liter of a 1 per cent. (w/v) solution?

472. A prescription calls for 1/100 grain of mercuric chloride in one fluidounce of a solution. Explain how you would proceed to dispense this amount.

473. How many minims of a saturated solution of potassium iodide would you use to make four fluidounces of a 15 per cent. (w/v) solution?

474. What volume of a 10 per cent. (w/v) solution of mercuric chloride solution would you use to make one pint of a 1:1000 solution?

61. Triturations

The Pharmacopœia gives directions for the manufacture of ten per cent. triturations. These are convenient for dispensing metric prescriptions and for obtaining decimal fractions of a grain. For ordinary dispensing a strength of 1 in 12 is more convenient. Especially when common fractional parts of a grain are desired.

475. Example. *A prescription for 12 pills requires 1/3 of a grain of strychnine sulphate. How many grains of a 1 in 12 trituration must be taken?*

One third of 12 is 4. Hence 4 grains of a 1 in 12 trituration will contain 1/3 of a grain.

Triturations are also used for obtaining fractions of a grain to be used in compounding liquids.

Problems

476. A prescription calls for $\frac{3}{4}$ grain of morphine sulphate. How many grains of a 1 in 12 trituration of morphine must be taken?

477. If $\frac{1}{6}$ of a grain of mercuric chloride is desired, how many grains of a 1 in 12 trituration must be taken?

478. How many grains of a 1 in 12 trituration will be required to obtain $\frac{2}{3}$ of a grain?

479. If a prescription calls for $\frac{1}{48}$ of a grain of strychnine sulphate to the fluid dram, how many grains of a 1 in 12 trituration will be required for a 4 fluidounce prescription?

480. If a 6 oz. prescription requires $\frac{1}{16}$ of a grain of morphine to the teaspoonful, how many grains of a 1 in 12 trituration must be taken?

481. How many grains of a trituration of morphine, 1 in 12, will be required to fill a 3 fluidounce prescription calling for 0.1 of a grain in each teaspoonful?

482. How many grams of a 1 in 10 trituration of mercuric chloride will be required to make a quart solution of 1:1000?

62. To Reduce Solutions from a Higher to a Lower Percentage

When per cent. by volume is used, the proportional parts are by volume. When per cent. by weight is used, the proportional parts are by weight.

When mixing liquids by volume that contract in volume when mixed, they should be allowed to stand until contraction ceases. Then add a sufficient quantity of the diluent to restore the required volume.

I. By Volume

483. Example. *Make 48.6 per cent. alcohol, by volume, from 94 per cent. alcohol, by volume.*

Let the required per cent. represent the volume of the strong liquid to be taken. Let the per cent. of the strong liquid represent the volume to which the strong liquid is to be diluted.

Thus take 48.6 volumes of 94 per cent. alcohol and add enough water to make 94 volumes.

II. *By Weight*

484. Example. *Make 41 per cent. alcohol, by weight, from 91 per cent. alcohol, by weight.*

Let the required per cent. represent the number of weight-parts of the strong liquid to be taken. Let the per cent. of the strong liquid represent the number of weight-parts to which the strong liquid is to be diluted.

Take 41 parts by weight of 91 per cent. alcohol and add sufficient water to make 91 parts by weight.

Problems

485. How many volumes of 60 per cent. alcohol are required to make 60 volumes of 40 per cent. alcohol?

486. How many grams of 28 per cent. ammonia water must be taken to make 28 grams of 10 per cent. ammonia water?

487. How many grams of strong sulphuric acid are required to make 92.5 grams of U. S. P. dilute sulphuric acid?

488. How many cubic centimeters of deodorized alcohol are required to make 95.1 cc. of U. S. P. dilute alcohol?

In the preceding problems the number of parts may be considered as proportional, and, if a greater or less quantity is desired, the proportional parts may be multiplied or divided by the same number, as the case may require. In problem 458, instead of making 60 volumes, 180 volumes may be made by taking 3 times 40 volumes, or 120 volumes, of 60 per cent. alcohol, and adding water to 3 times 60 volumes, or 180 volumes. Again 15 volumes may be made by taking one-fourth of 40 volumes, or 10 volumes, of 60

per cent., and adding water to one-fourth of 60 volumes, or 15 volumes. The preceding is identical in practice with the following:

63. To Make a Given Quantity of Solution of a Given Strength by Diluting a Strong Solution

489. Example. *Make 370 grams of 10 per cent. sulphuric acid from 92.5 per cent. sulphuric acid.*

$370 \times 0.10 = 37$, the quantity of absolute acid required.

$37 \div 0.925 = 40$, the number of grams of 92.5 per cent. sulphuric acid required.

$370 - 40 = 330$, the number of grams of water required.

Or by proportion: $92.5 : 10 :: 370 : x = 40$. $370 - 40 = 330$ grams.

Problems

490. How many grams of glacial acetic acid are required to make 770 grams of 36 per cent. acid?

491. How many cubic centimeters of 94 per cent. alcohol must be taken to make 517 cc. of 50 per cent. alcohol?

492. How many Imperial fluidounces of 94 per cent. alcohol are required to make 23.5 Imperial fluidounces of 40 per cent. alcohol?

493. How many avoirdupois ounces of 68 per cent. nitric acid are required to make 17 av. oz. of 10 per cent. acid?

494. How many grams of 32 per cent. hydrochloric acid must be taken to make 192 grams of 10 per cent. acid?

495. How many grains of 20 per cent. mercury oleate and oleic acid are required to make one apothecaries ounce of 5 per cent. mercury oleate?

496. How many grams each of 18 per cent. opium and lactose are required to make 126 grams of 14 per cent. opium?

497. How many grams of 86 per cent. phosphoric acid and water will be required to produce a pound of 10 per cent. acid?

498. In what proportion must 7 per cent. mercuric chloride solution and water be mixed to produce a 0.05 per cent. solution?

64. To Reduce a Given Quantity of a Substance, of a Given Per Cent., to a Lower Per Cent.

499. Example. *Dilute 240 grams of 92 per cent. sulphuric acid to 12 per cent. acid.*

$240 \times 0.92 = 220.8$ grams of absolute sulphuric acid.

$220.8 \div 0.12 = 1840$ grams of 12 per cent.

$1840 - 240 = 1600$ grams of water to be added.

Or by proportion: $12:92::240:x=1840$. $1840 - 240 = 1600$.

Problems

500. How many cubic centimeters of 48 per cent. alcohol can be made from 500 cc. of 94 per cent. alcohol?

501. How many avoirdupois ounces of 20 per cent. solution of zinc chloride can be made from 4 avoirdupois ounces of 50 per cent. solution of zinc chloride?

502. How many drams of 6 per cent. mercury oleate may be made from 12 drams of 20 per cent. mercury oleate?

503. How many grams of water must be added to 45 grams of 36 per cent. acetic acid to reduce it to 6 per cent.?

504. How many avoirdupois ounces of dilute hydrochloric acid can be made from 4 avoirdupois ounces of U. S. P. hydrochloric acid?

505. How many grams of 36 per cent. acetic acid can be made from 127 grams of 98 per cent. acid?

506. How many fluidounces of water must be added to one pound of 12 per cent. solution of potassium hydroxide to reduce it to 5 per cent.?

507. How many fluidounces of water must be added to 200 grams of 36 per cent. acetic acid to reduce it to 6 per cent.?

508. How many grams of 5 per cent. zinc chloride solution can be made from 25 cc. of a 50 per cent. solution, sp. gr. 1.548?

509. How much water must be added to a fluidounce of a 50 per cent. solution of zinc chloride solution, sp. gr. 1.548, to reduce it to a 3 per cent. solution?

510. How many fluidounces of 10 per cent. ammonia water can be prepared from half a pint of stronger ammonia water?

511. How many fluidounces of 10 per cent. phosphoric acid can be made from four ounces of 85 per cent. acid?

512. How many grams of a mixture of magnesium oxide and starch must be added to 200 grams of a dry extract of hydrastis which contains 12.5 per cent. of alkaloid to reduce it to 10 per cent.?

65. Alligation Medial

Alligation medial is the process of finding the average value of a mixture of different values.

513. Example. *A pharmacist prepares a mixture that contains 6 ounces of a drug that costs 8 cents an ounce; 2 ounces that costs 5 cents an ounce; 4 ounces that costs 3.5 cents an ounce. What is the average cost of the mixture?*

6 oz. at 8	cts. cost	$6 \times 8 = 48$
2 " " 5	" "	$2 \times 5 = 10$
4 " " 3.5	" "	$4 \times 3.5 = 14$
12		72

Therefore, if 12 ounces cost 72 cents the average cost will be $\frac{1}{12}$ of 72, or 6 cents, since $72 \text{ cents} \div 12 = 6 \text{ cents per ounce}$.

Problems

514. A manufacturer has recovered 5 gallons of 92 per cent. alcohol, 8 gallons of 60 per cent., 3 gallons of 30 per cent. and 2 gallons of 75 per cent. What is the strength of the mixture?

515. If you compound a mixture containing 2 ounces of a drug that cost \$560 a pound 4 ounces of another that cost 64 cents a pound; 6 ounces of another that cost 56 cents a pound; and 5 ounces that cost 40 cents a pound, what is the average cost per ounce?

516. If a powder contains 40 grains of a drug that cost 60 cents an ounce, 60 grains at 8 cents an ounce, and 90 grains at \$1.20 an ounce, what will one dram of the mixture cost?

517. For equal amounts of cinchona, containing 4, 6.5, 8.5, and 10 per cent. of total alkaloids respectively, were mixed. What was the strength of the mixture?

518. A pharmacist in the process of manufacture recovers a quart of 45 per cent. alcohol, a pint of 60 per cent. alcohol, 30 oz. of 75 per cent. alcohol, and 20 oz. of 35 per cent. alcohol. When these were mixed what was the strength of the mixture?

519. Three samples of opium are mixed, the first consisted of 5 oz. of 8 per cent. morphine, the second 6 oz. of 9 per cent., the third 4 oz. of 12 per cent. What is the strength of the mixture?

520. What will be the specific gravity of a mixture containing 4 fl. oz. of sulphuric acid, sp. gr. 1.652, 6 fl. oz., sp. gr. 1.253, 7 fl. oz., sp. gr. 1.165?

521. What is the specific gravity of a mixture of the following alcoholic distillates: 1 pint, sp. gr. 0.935, 12 oz., sp. gr. 0.835, 2 pints, sp. gr. 0.875, 24 oz., sp. gr. 0.905?

ALLIGATION

The application of the principles of alligation to the practice of pharmacy admits of extended use.

Alligation, as applied to pharmacy, is the method of ascertaining the quantities of substances of different strengths required to be mixed in order to produce a certain mixture of a given strength.

Every alligation problem must contain a higher or a stronger term to be mixed with a lower, or a weaker term to produce one of intermediate or required strength.

66. Alligation Applied to Pharmacy

522. Example. *In what proportion must 12 per cent. and 17 per cent. powdered opium be mixed to produce a 14 per cent. opium?*

As we are to obtain an intermediate strength we first find what part of each must be taken, so that the gain and loss will each equal one unit.

Since 14 per cent. is required, if one part of 17 per cent. and one part of 12 per cent. are mixed the increase in strength in one case is 3 per cent. and the decrease in strength in the other is 2 per cent. Therefore, to make the increase and decrease equal, $\frac{1}{3}$ of a part of 17 per cent. must be taken to gain 1 per cent., and $\frac{1}{2}$ of a part of 12 per cent. must be taken to decrease the strength 1 per cent. Hence, if $\frac{1}{3}$ of a part of 17 per cent. and $\frac{1}{2}$ of a part of 12 per cent. are mixed, a 14 per cent. opium will be made.

As the fractions are proportional parts we may take any number of times $\frac{1}{3}$ and $\frac{1}{2}$, if both terms are multiplied by the same number, and the strength of the product will not be changed. Advantage is taken of this fact in the

changing of the fractions to whole numbers. This is done by multiplying the fractions by the least common multiple of their denominators, which is 6. We then have :

14	17	$1/3 \times 6 = 2,$	2 parts of 17% opium
	12	$1/2 \times 6 = 3,$	3 parts of 12% opium
			Make 5 parts of 14% opium

From the preceding we derive the following :

Find the quantity, the strength of which is greater than the mean rate, that must be taken to gain one of the same denomination as the mean rate. Find the quantity, the strength of which is less than the mean rate, that must be taken to lose one of the same denomination as the mean rate. Change the fractions, if there are any, to whole numbers. The result is the number of parts of each that must be taken to produce the mean rate.

Problems

523. In what proportion must a 6 per cent. and a 14 per cent. drug be mixed to produce one of 8 per cent.?

524. In what proportion must 92 per cent. alcohol and 20 per cent. alcohol be mixed to produce 40 per cent. alcohol?

525. Mix 8 per cent. and 28 per cent. ammonia water to make 10 per cent. ammonia water.

526. In what proportion must 28 per cent. ammonia water and water be mixed to produce 10 per cent. ammonia water?

527. In what proportion must 28 and 16 per cent. hydrochloric acid be mixed to produce 18 per cent.?

528. In what proportion must lactose be added to 18 per cent. opium to reduce it to 12 per cent.?

529. In what proportion must 98 per cent. phenol be mixed with water to reduce it to 88 per cent.?

530. If two samples of opium contain, respectively 16 and 11

per cent. of morphine. In what proportion must they be mixed to produce a 14 per cent. opium?

531. In what proportion must glycerin be added to 88 per cent. liquid phenol to reduce it to 18 per cent.?

532. In what proportion must 4 per cent. cinchona be mixed with 7 per cent. cinchona to reduce the latter to 5 per cent.?

533. If two samples of drug cost 65 and 85 cents a pound, in what proportion must they be mixed to produce a mixture costing 72 cents a pound?

534. A 60 per cent. menstruum is desired. In what proportion must 45 and 82 per cent. alcohol be used?

In the demonstration of the preceding example observe that the number in the final result, in each case, is the same as the figure of the denominator of the fraction of the substance with which it is to be mixed. From which we deduce the following:

Subtract the required per cent. from the greater per cent. and place the difference opposite the lower per cent. Also subtract the lower per cent. from the required per cent. and place the difference opposite the greater per cent. The figures opposite each are the required result.

Thus:

14	|	17	|	2,	2 parts of 17%
		12		3,	3 parts of 12%
					<u>5 parts of 14%</u>

When per cent. by weight is used, the proportionate parts are by weight. When per cent. by volume is used, the proportionate parts are by volume.

When mixing liquids by measure that contract in volume when mixed, they should be allowed to stand until contraction ceases. Then add sufficient quantity of the diluent to make the required volume.

67. To Find the Amounts Necessary to Make a Given Quantity

The preceding results are proportional parts and any multiple of them may be taken so long as their relative proportions are retained. Therefore, if it is desired to make a given amount, it is only necessary to take as many times the number of parts as their sum is contained times in the required amount.

535. Example. *How many ounces of 12 and 18 per cent. powdered opiums are required to make 24 ounces of 14 per cent. opium?*

14	18	2	1 part of 18 per cent. opium
	12	4	2 parts of 12 per cent. opium
			3 parts of 14 per cent. opium

Since the sum of the parts is 3, to make 24 ounces we must take as many times the number of parts of each as 3 is contained in 24, which is 8.

$8 \times 1 = 8$, or 8 oz. of 18 per cent. opium.

$8 \times 2 = 16$, or 16 oz. of 12 per cent. opium.

$8 + 16 = 24$, ounces of 14 per cent. opium.

Or by proportion,

$3:24::1:x, x = 8$ oz. of 18 per cent. opium.

$3:24::2:x, x = 16$ oz. of 12 per cent. opium.

Problems

536. How many grams of 16 per cent. and 10 per cent. opiums must be used to make a kilogram of 14 per cent. opium?

537. How many grams of lactose must be mixed with a 25 per cent. triturate to produce 10 grams of a 10 per cent. triturate?

538. How many fluidounces of water and 28 per cent. ammonia water are required to make one quart of 10 per cent. ammonia

water? As the per cent. of ammonia gas is by weight, a correction must be made for the difference in specific gravity.

539. How many grams of 1.5 per cent. and 4 per cent. hydrogen peroxide water must be mixed to make 100 grams of 3 per cent. hydrogen peroxide water?

540. How many avoirdupois ounces of U. S. P. hydrochloric acid and water must be mixed in order to produce one pint of 10 per cent. hydrochloric acid?

541. How many ounces of a 6 per cent. and 12 per cent. triturate will be required to make a pound of 10 per cent. triturate?

542. How many cubic centimeters of 92 per cent. and 40 per cent. alcohol will be required to make 2 liters of 50 per cent. alcohol?

543. Find the amount of hydrochloric acid, 31 per cent., and water required to make one gallon of 10 per cent. acid.

544. How many apothecaries ounces of 86 per cent. phosphoric acid and water will be required to make a pint of 10 per cent. phosphoric acid?

68. To Find the Amount of One Ingredient when the Amount of the Other Is Given

545. *Example. How many ounces of lactose must be mixed with 20 ounces of a 12 per cent. triturate to make a 5 per cent. triturate?*

$$5 \quad \left| \begin{array}{c|c} 12 & 5 \\ \hline 0 & 7 \end{array} \right| \quad \left| \begin{array}{c} 20 \div 5 = 4 \end{array} \right|$$

Seven parts of lactose are required for every five parts of triturate; as there are 20 parts of triturate it will require 4×7 , or 28 parts of lactose.

Or by proportion : $5 : 20 :: 7 : x, x = 28$.

Problems

546. How many avoirdupois ounces of water must be added to 30 avoirdupois ounces of 25 per cent. nitric acid to produce a 5 per cent. nitric acid?

547. How many grams of 20 per cent. alcohol must be added to 1000 grams of 80 per cent. alcohol to make a 55 per cent. alcohol?

548. Given 10 apothecaries ounces of 91 per cent. alcohol, to make a 45.5 per cent. alcohol. How many ounces of 20 per cent. alcohol are required?

549. Desired to make a solution containing 20 per cent. of hydrochloric acid, using 80 grams of strong U. S. P. acid, and a sufficient quantity of dilute U. S. P. acid. How many grams of the latter are required?

550. How many ounces of 92 per cent. alcohol must be added to 100 ounces of 30 per cent. alcohol to make a 50 per cent. alcohol?

551. Given 25 ounces of 15 per cent. alcohol, to make 45 per cent. alcohol. How many ounces of 85 per cent. alcohol are required?

552. How much water must be added to 1 pound of 36 per cent. acetic acid to reduce it to 6 per cent.?

553. How much water must be added to 100 cc. of 92.5 per cent. sulphuric acid to make the official 10 per cent. acid?

554. How much opium, containing 8 per cent. of morphine, must be mixed with 10 ounces of 17 per cent. opium to make a mixture containing 12 per cent.?

555. How much alcohol, 35 per cent. by weight, can be made from one quart of 92.3 per cent. by weight?

556. How much alcohol, 94.9 per cent. by volume, must be added to 2 pints of alcohol, 70 per cent. by volume, to make an alcohol containing 87.8 per cent. by volume?

69. When More than Two Substances of Different Strengths Are to Be Mixed

557. Example. *In what proportion must 8, 10, 16, and 18 per cent. opiums be mixed to form a 14 per cent. opium?*

Write the per cents. in a column. Connect each one of the terms which is less than that of the required term with one that is greater. Solve each couplet as before.

$$14 \quad \left[\begin{array}{c|c} 8 & 4 \\ 10 & 2 \\ 16 & 4 \\ 18 & 6 \end{array} \right] \left[\begin{array}{c} 2, 2 \text{ parts of } 8 \text{ per cent. opium} \\ 1, 1 \text{ parts of } 10 \text{ per cent. opium} \\ 2, 2 \text{ parts of } 16 \text{ per cent. opium} \\ 3, 3 \text{ parts of } 18 \text{ per cent. opium} \end{array} \right]$$

When solving the above problem by the first method, the fractions in each couplet should be changed to whole numbers separately.

Thus:

$$14 \quad \left[\begin{array}{c|c|c|c|c} A & B & C & D & E \\ 8 & 1/6 & & 2 & \\ 10 & & 1/4 & & 1 \\ 16 & & 1/2 & & 2 \\ 18 & 1/4 & & 3 & \end{array} \right]$$

Multiplying *B* by the least common multiple of its denominators, which is 12, we have *D*. Multiplying *C* by the least common multiple of its denominators, which is 4, we have *E*.

When an odd number of substances is used, or when the number of weaker per cents. exceed the stronger, or vice versa, some of the terms must be used more than once. Thus:

558. Example. *In what proportion must 8, 16, and 18 per cent. opiums be mixed to form a 14 per cent. opium?*

$$14 \quad \left[\begin{array}{c|c|c|c} 8 & 2 & 4 & 6 \\ 16 & 6 & & 6 \\ 18 & & 6 & 6 \end{array} \right] \left\{ \begin{array}{l} 1 \text{ part of } 8\% \text{ opium} \\ 1 \text{ part of } 16\% \text{ opium} \\ 1 \text{ part of } 18\% \text{ opium} \end{array} \right\} = 3 \text{ parts of } 14\% \text{ opium.}$$

Problems

559. A pharmacist has 400 grams of opium containing 10 per cent. of morphine, 350 grams of opium containing 12 per cent. of morphine. How much opium of 16 per cent. morphine must he add to a mixture of the two to make a product containing 13 per cent. of morphine?

560. If 5 pounds of cinchona containing 7 per cent. of quinine is mixed with 3 pounds of cinchona containing 8.4 per cent. of

quinine, how much cinchona, containing 4.5 per cent. of quinine, must be added to the mixture to reduce it to 6 per cent.?

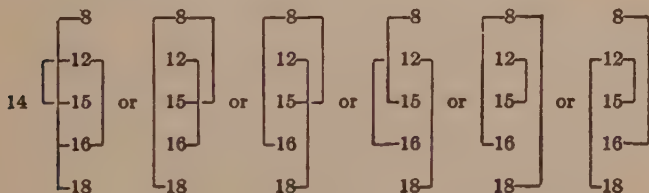
561. In what proportion must 50 per cent., 35 per cent. acid and water be mixed to produce a 10 per cent. acid?

562. In what proportion must three samples of cinchona be mixed to produce a mixture containing 5 per cent. of quinine, if the samples contain 6.44, 4.48 and 3.68 per cent. of quinine?

563. If two samples of opium containing 14.5 and 16 per cent. of morphine are mixed, in what proportion must lactose be added to reduce the mixture to 12 per cent.?

When there are several different terms, as many different results may be obtained as different couplets can be formed.

564. Example. Obtain different results by mixing 18, 16, 15, 12, and 8 per cent. to form 14 per cent. Thus:



The student may secure as many different results as possible from the following problems.

Problems

565. In what proportion, by volume, must 90, 85, 80, 45, 30, 25, and 20 per cent. alcohols be mixed to produce a 40 per cent. alcohol?

566. Mix 92, 84, 16, and 8 per cent. sulphuric acids to produce a 48 per cent. acid by weight.

567. In what proportion must powdered nux vomica, assaying 1.03, 1.1, 1.32, and 1.28 per cent. of strychnine, be mixed in order to obtain a product containing 1.25 per cent. of strychnine?

568. Find the number of grams of hydrochloric acid, containing 31, 25, 15, and 5 per cent., required to make a liter of 10 per cent.

70. When the Quantities of More than One of the Terms Are Given

569. *Example.* How many grams of water are required to make a 10 per cent. sulphuric acid from 25 grams of 30 per cent. and 50 grams of 60 per cent. sulphuric acids?

If we mix 25 grams of 30 per cent. with 50 grams of 60 per cent., we will have 75 grams of 50 per cent. Thus:

$$\begin{array}{r}
 25 \times 30 = 750 \\
 50 \times 60 = 3000 \\
 \hline
 75 \qquad 3750 \qquad 3750 \div 75 = 50
 \end{array}$$

The question now becomes, how many grams of water are required to make 10 per cent. sulphuric acid from 75 grams of 50 per cent. sulphuric acid?

$$\begin{array}{c|c|c|c}
 10 & 50 & 10 & 1 \text{ part of 50 per cent. sulphuric acid} \\
 & 0 & 40 & 4 \text{ parts of water}
 \end{array}$$

If 1 gram of 50 per cent. sulphuric acid requires 4 grams of water, 75 grams will require 75 times 4 grams, or 300 grams of water.

Or by proportion: $1:4::75:x$, $x = 300$ grams of water.

Problems

570. How many grains of 18 per cent. opium must be mixed with 50 grains of 12 per cent., 80 grains of 13 per cent., and 40 grains of 10 per cent. opiums to make powdered opium containing 14 per cent. morphine?

571. A pharmacist has recovered 200 cc. of alcohol, having a specific gravity of 0.8526, and 450 cc. of alcohol having a specific gravity of 0.909. How many cc. of alcohol, 92 per cent., must be added to make an 88 per cent. alcohol?

Note.—From the alcohol tables of the Pharmacopœia find the per cent. by volume corresponding to the specific gravities, given at 15.56° C., and proceed as before.

572. How many grams of oleic acid must be added to 10 grams of 20 per cent. and 25 grams of 15 per cent. oleates of mercury to make a 5 per cent. oleate of mercury?

573. How many avoirdupois ounces of carbolic acid, 95 per cent., is it necessary to add to 12 ounces of 5 per cent. and 16 ounces of 12 per cent. to make a solution containing 15 per cent. of carbolic acid?

574. If 5 pounds of cinchona containing 4.5 per cent. of quinine are mixed with 7 pounds containing 8.4 per cent. of quinine, how much cinchona containing 5 per cent. of quinine must be added to reduce the mixture to 6 per cent.?

575. How much 16.5 per cent. opium must be mixed with 4 ounces of 10 per cent. and 5 ounces of 11 per cent. to make the mixture 14 per cent.?

576. How much lactose must be added to 75 grams of 14 per cent. and 15.5 grams of 15.5 per cent. opium to reduce the mixture to 12 per cent.?

577. If you have a mixture of 350 grams of 65 per cent., 240 grams of 34 per cent., and 100 grams of 8 per cent. sulphuric acids, how much water must be added to produce a 10 per cent.?

578. How many cubic centimeters of 10 per cent. acid, sp. gr. 1.067, can be made by diluting 250 grams of 60 per cent. and 125 grams of 45 per cent. acids, with water?

Alligation may also be expressed in the following form (compare Problem 530, Sec. 66) :

14			
8	10	16	18
4	2	4	6
2	1	2	3

Therefore, 2 of 8 per cent., 1 of 10 per cent., 2 of 16 per cent., and 3 of 18 per cent. must be mixed to produce 14 per cent.

71. Alligation Applied to the Mixing of Liquids of Different Specific Gravities

Alligation may be employed in mixing liquids of different specific gravities, when no change in volume occurs. The process is the same as in articles 63 to 67, except that specific gravities are used in place of per cents. *The ratios are by volume.*

579. Example. *In what proportion must glycerin, specific gravity 1.25, and water be mixed to produce a specific gravity of 1.10?*

1.10	1.25	10	2 parts of glycerin
	1.00	15	3 parts of water

Problems

580. How many cubic centimeters of hydrochloric acid, specific gravity 1.20, must be mixed with 150 cc. of hydrochloric acid, specific gravity 1.10, to produce an acid having a specific gravity of 1.16?

581. How many cc. of water must be added to 84 cc. of nitric acid, sp. gr. 1.42, to make an acid having a sp. gr. of 1.075?

582. How much solution of ferric chloride, sp. gr. 1.52 and sp. gr. 1.28, are required to make 32 fluidounces of a solution having a sp. gr. of 1.387?

583. How many cubic centimeters of water will be required to reduce 500 cc. of solution of subsulphate of iron, sp. gr. 1.542, to sp. gr. 1.286?

No dependence can be placed on the results in the case of liquids that contract in volume on being mixed, as the following example will serve to illustrate:

584. Example. *How many cc. of alcohol, specific gravity 0.812, and water must be mixed to produce 1000 cc. of alcohol having a specific gravity of 0.93?*

$$\begin{array}{r|l}
 0.93 & \begin{array}{l} 0.812 \quad 7 \\ 1.000 \quad 11.8 \end{array} \\
 \hline
 & 1000 \div 18.8 = 53.19 \\
 & 7 \times 53.19 = 372.33 \text{ cc. of alcohol} \\
 & 11.8 \times 53.19 = 627.64 \text{ cc. of water} \\
 & \hline
 & 999.97
 \end{array}$$

According to the above calculation, if 372.33 cc. of alcohol are mixed with 627.64 cc. of water, 999.97 cc. of a mixture having a specific gravity of 0.93 should be produced, but in actual practice it produces 976 cc. of a mixture having a specific gravity of 0.953.

In order to produce an alcohol having a specific gravity of 0.93, equal volumes of alcohol and water must be mixed. While the difference in specific gravity may appear but slight, the actual difference in strength of the two mixtures amounts to 12.7 per cent. by volume of alcohol.

72. Commercial Discount

Commercial Discount is a percentage deduction from the price of an article. Manufacturers and wholesalers issue price lists with statements concerning the discounts which they allow on different classes of goods, as well as the discounts for definitely timed cash payments of invoices. Frequently, several discounts are allowed the purchaser. In such cases, the first discount is deducted, then the second is computed upon the remainder and deducted, a similar procedure being followed for each successive discount.

The amount of a statement less the discounts is called the *Net Amount*.

585. Example. *A certain fluidextract is listed at \$6.40 per gallon, less 40% and 2% for cash, 10 days. What is the net cost to the pharmacist?*

$$\begin{aligned} .40 \times \$6.40 &= \$2.56 \\ \$6.40 - \$2.56 &= \$3.84 \\ .02 \times \$3.84 &= \$0.0768 \\ \$3.84 - \$0.08 &= \$3.76, \text{ net cost.} \end{aligned}$$

Problems

586. On a bill of goods amounting to \$160.00, what is the difference between a discount of 40 per cent. and successive discounts of 25 per cent., 10 per cent., and 5 per cent.?

587. If an ointment is listed at \$1.10 per pound, less 40 per cent., what will five pounds cost?

588. If a case containing three gross of bottle costs \$24.00, less 10 per cent, 5 per cent, and 2 per cent., what will one bottle cost?

589. A bill of goods amounts to \$250, less discounts of 12 per cent. and 5 per cent. What is the net amount of the bill? What single discount is equivalent to the two successive discounts stated above?

590. If a gross of cough syrup costs \$24.26, less 10 per cent. with one dozen free, what is the cost per bottle?

591. If the cash discount on a bill of goods is 5 per cent. and amounts to \$10.80, what is the gross amount of the bill? What is the net amount?

592. During a special sale on hot water bottles, a pharmacist offered to his customers a 25 per cent. discount from the original selling price. The discount amounted to 50 cents on each bottle. What was the original selling price? What was the sale price?

593. What is the list price of a bill of goods on which discounts of 40 per cent. and 5 per cent. are allowed, if the total discount amounts to \$46.44? What is the net amount?

594. If a bill of goods costs \$93.48 after discounts of 40 per cent. and 5 per cent. are deducted, what was the original amount of the bill?

595. A pharmacist can realize a discount of 2 per cent. on a bill of goods amounting to \$600 if he pays cash within ten days. He borrows the money at 5 per cent. interest for 30 days. How much does he save?

73. Profit and Loss

Every retail pharmacist is in business to serve his customers. That service is entitled to the proper remuneration known as profit.

Gross Profit is the difference, or "spread" between the cost of an article of merchandise and its selling price. Also known as *Margin*.

Operating Expense, or "overhead," is the amount paid out as the cost of conducting a business.

Net Profit is the difference obtained by subtracting the operating expense from the gross profit.

Mark-Up is the percentage by which the cost of an article is multiplied to obtain the amount which, added to the cost of the article, gives the selling price.

Turnover is a figure which represents the number of times a given amount of merchandise is sold within a given length of time.

Inventory is an itemized list of goods with their estimated value.

Depreciation is an amount which represents the reduction in sale value.

Gross profit should be figured on the selling price of an article. This holds true because no profit is made until the sale is made; because all other retail business figures are based on their relation to sales, and all business figures should be uniform; because discounts to customers are always based on the selling price; because total sales for any given period of time are usually available.

Problems

596. A certain brand of toothbrushes costs the pharmacist \$18.00 per gross. They sell for 25 cents each. What is the per cent. of gross profit, or margin, based on selling price?

597. If the overhead expense of the store is 25 per cent., based on sales, what is the net cash profit on the entire gross of toothbrushes in the above problem?

598. Example. *If an article costs \$2.00 per dozen, at what price must it be sold to yield a net profit of $8\frac{1}{3}\%$, if the cost of doing business is 25%?*

$$25\% + 8\frac{1}{3}\% = 33\frac{1}{3}\%.$$

100% equals the selling price.

$$100\% - 33\frac{1}{3}\% = 66\frac{2}{3}\%, \text{ or the cost.}$$

Therefore \$2.00 equals 66% of the selling price.

$$\$2.00 \div 66\frac{2}{3}\% = 3 \text{ cents, or } 1\% \text{ of the selling price.}$$

$$100 \times 3 \text{ cents} = \$3.00, \text{ the selling price of one dozen.}$$

$$\$3.00 \div 12 = \$.25, \text{ selling price of one article.}$$

Problems

599. A certain proprietary preparation costs 90 cents and the pharmacist wishes to make 40 per cent. on the selling price of this item. At what price must it be sold?

600. If the cost of doing business is 25 per cent. of the gross sales, what should a pharmacist pay for an article retailing for \$2.60, if he wishes to make a net profit of 10 per cent.?

601. A pharmacist paid \$2500 for his prescription department fixtures. If they depreciate at the rate of 25 per cent. the first year and 10 per cent. each year thereafter, what is their inventory value at the end of four years?

602. What per cent. of the cost of an article must be taken to obtain its selling price if the cost is 60 cents and the desired profit is 36 cents.

603. If the proper amount of syrup for a glass of soda water costs $\frac{7}{8}$ of a cent and the clerk puts in 10 per cent. more than he should, what is the loss on 300 glasses?

604. If a pharmacist finds that he can make 40 per cent. on the selling price if he buys perfume at \$1.50 per bottle, what per cent. profit does this represent if based on the cost price?

605. If you purchase 453.6 Gms. of ether for 40 cents, at what price must you sell four avoirdupois ounces in order to make a profit of 50 per cent., based on the selling price?

606. If it costs 25 per cent. of gross sales to operate a certain

retail pharmacy and an article is sold for \$1.25 that cost \$1.00 wholesale, what is the gain or loss? What is the percentage of gain or loss?

Turnover is determined by dividing the total sales over a given period of time (usually a year) by the average inventory at selling prices for the same period of time. Or, by dividing the total sales at cost of goods sold by the average inventory at cost of goods purchased.

The cost of goods sold is determined by subtracting the inventory at the end of the year from the sum of the inventory at the beginning of the year and the purchases during that period.

The average inventory is determined by adding the inventory at the beginning of the year to the inventory at the end of the year and dividing by two.

607. Figures in the statement of a certain drug store for a given year were as follows:

Sales for the year	\$45,362.94
Inventory at the beginning of the year..	13,435.80
Purchases during the year.....	30,108.20
Inventory at the end of the year.....	13,309.10
Current expense, including proprietor's salary	11,340.74
Proprietor's salary	3,000.00
Gross profit	15,128.04

Find cost of goods sold, average inventory, turnover, net profit, total income from the business. Percentage figures for : current expense (overhead), gross profit, and net profit.

ATOMIC AND MOLECULAR WEIGHTS

Elements are made up of infinitesimal particles called atoms. There are as many different kinds of atoms as there are elements. An atom is the smallest particle of an element that can enter into the composition of a molecule. A molecule is the smallest particle into which a substance can be divided without losing its identity. Molecules unite to form matter. If matter has weight it follows that molecules and atoms have weight. The relative weights of these atoms, compared with oxygen 16 as a unit, are their atomic weights.

Symbols are used to represent the elements. Each symbol represents one atom of the element, and as each atom has a definite weight, then each symbol must represent a definite weight of the element. As molecules are made up of atoms, it follows that the molecular weight of a substance must be equal to the sum of the weights of the atoms of which it is composed.

Molecules may contain atoms of like or unlike elements. The molecules of nearly all of the elements contain two atoms; therefore, their molecular weight is twice their atomic weights. The following are the principal exceptions:

Mercury, cadmium, zinc, sodium, and potassium are monatomic; therefore, their molecular weights are the same as their atomic weights. Phosphorus and arsenic are tetraatomic; therefore, their molecular weights are four times their atomic weights.

A list of elements and chemicals used in this book, with formulas, atomic and molecular weights, may be found on pages 163, 164 and 165.

74. To Find the Molecular Weight of a Substance from Its Formula

608. *Example.* What is the molecular weight of sodium phosphate? One molecule contains $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$. The

atomic weight of sodium is 23; hydrogen, 1.008; phosphorus, 31.04; oxygen, 16.

2	atoms of Na weigh	2×23	=	46.
25	" " H	" 25×1.008	=	25.2
1	" " P	" 31.04	=	31.04
16	" " O	" 16×16	=	256.
				358.24 molecular weight

For Table of Atomic and Molecular Weights used in this book see pages 163, 164 and 165.

Atomic weights are relative weights. Therefore, they may be adapted to the use of any system of weights, or weights of any size. In the sodium phosphate already given, the quantities obtained may be used equally well as grams, grains, ounces, or pounds. If grains were taken, then 358.24 grains of sodium phosphate would contain 46 grains of sodium, 25.2 grains of hydrogen, 31.04 grains of phosphorus, and 256 grains of oxygen.

Problems

Find the molecular weights of the following:

609. Sodium nitrate.

610. Water.

611. Anhydrous ferrous sulphate.

612. Crystallized ferrous sulphate.

613. Potassium bromide.

When elements unite in chemical combination they do so in a definite ratio. If we let grams represent atomic weights of the elements of water we have one atom, 16 grams, of oxygen united with two atoms, 2.016 grams, of hydrogen in the formation of one molecule, or 18.016 grams of water. Any number of times these amounts may be taken so long as the ratio of 16 to 2.016 is maintained.

75. To Find the Percentage Composition of a Substance when the Molecular Formula Is Given

614. Example. *What is the percentage composition of sodium phosphate?*

In the preceding section we found the molecular weight of sodium phosphate and the weight of each element in the molecule. Since the elements are combined in a definite ratio, and the weights are relative, it follows that if 358.24 units of sodium phosphate contain 46 units of sodium, one unit will contain $\frac{1}{358.24}$ of $46 = 0.12839$ of sodium. One hundred units will contain 100×0.12839 , or 12.839 per cent. of Na.

$$\frac{1}{358.24} \text{ of } 25.2 \times 100 = 7.034 \text{ per cent. of H}$$

$$\frac{1}{358.24} \text{ of } 31.04 \times 100 = 8.6589 \text{ per cent. of P}$$

$$\frac{1}{358.24} \text{ of } 256 \times 100 = 71.46 \text{ per cent. of O}$$

Or by proportion:

$$\begin{array}{llll} \text{Na}_2\text{HPO}_4.12\text{H}_2\text{O} : & \text{Na} \times 2 & :: 100 : x \\ 358.24 & : 46 & :: 100 : 12.839 \text{ per cent. of Na} \\ \text{Na}_2\text{HPO}_4.12\text{H}_2\text{O} : & \text{H} \times 25 & :: 100 : x \\ 358.24 & : 1.008 \times 25 & :: 100 : 7.034 \text{ per cent. of H} \\ \text{Na}_2\text{HPO}_4.12\text{H}_2\text{O} : & \text{P} & :: 100 : x \\ 358.24 & : 31.04 & :: 100 : 8.659 \text{ per cent. of P} \\ \text{Na}_2\text{HPO}_4.12\text{H}_2\text{O} : & \text{O} \times 16 & :: 100 : x \\ 358.24 & : 16 \times 16 & :: 100 : 71.46 \text{ per cent. of O} \end{array}$$

Problems

Find the percentage composition of the following:

615. Benzoic acid, $\text{HC}_7\text{H}_5\text{O}_2$.

616. Sodium chloride, NaCl .

- 617. Alcohol, C_2H_6O .
- 618. Ammonia gas, NH_3 .
- 619. Zinc sulphate, $ZnSO_4$.
- 620. Water, H_2O .
- 621. Morphine, $C_{17}H_{23}NO_3$.
- 622. Paraldehyde, $C_6H_{12}O_3$.

76. To Find the Percentage of Two or More Elements in a Substance when Its Formula Is Given

623. Example. *What per cents. of sulphuric anhydride, SO_3 , and barium oxide, BaO , are present in barium sulphate, $BaSO_4$?*

This is similar to the preceding, except that the sum of the atomic weights of the elements, of which the percentage is desired, is used in place of the atomic weight of each element.

$$\begin{array}{l} BaSO_4 : BaO :: 100 : x \\ 233.44 : 153.37 :: 100 : 65.69 \text{ per cent. of } BaO \\ BaSO_4 : SO_3 :: 100 : x \\ 233.44 : 80.07 :: 100 : 34.3 \text{ per cent. of } SO_3. \end{array}$$

Problems

624. What per cent. of water is present in crystallized phosphate of sodium, $Na_2HPO_4 + 12H_2O$?

625. What per cent. of potassium chloride, KCl , may be obtained from potassium chlorate, $KClO_3$, if the oxygen is driven off by heat?

626. Ammonia gas forms what per cent. of ammonium chloride?

627. What per cent. of crystallized sodium carbonate, $Na_2CO_3 + 10H_2O$, is anhydrous sodium carbonate?

628. When crystallized ferrous sulphate is heated to $115^\circ C$. it loses 6 molecules of water of crystallization. What per cent. is lost?

629. What per cent. of anhydrous copper sulphate is present in the crystallized copper sulphate?

630. What per cent. of carbon dioxide can be liberated from calcium carbonate?

631. What per cent. of calcium oxide is left after igniting calcium carbonate?

632. What per cent. of water and anhydrous sodium phosphate does crystallized sodium phosphate contain?

77. To Find the Weight of One or More Elements in a Given Quantity of Substance

633. **Example.** *How much bromine is there in 12 ounces of potassium bromide?*

The molecular weight of potassium bromide is 119.02. The atomic weight of bromine is 79.92.

If 119.02 units of potassium bromide contain 79.92 units of bromine, one unit, or one ounce, will contain

$$\frac{1}{119.02} \text{ of } 79.92 = 0.6714$$

$$12 \times 0.6714 = 8.05 \text{ ounces of bromine}$$

Or by proportion :

$$\text{KBr} : \text{Br} :: 12 : x$$

$$119.02 : 79.92 :: 12 : 8.05 \text{ ounces of bromine}$$

The following statement of proportion applies to all problems involving atomic and molecular weights, where the quantity of one is given and another is desired :

Place the molecular or atomic weight of the substance of which the quantity is given in the first place. The molecular or atomic weight of the substance of which the quantity is desired in the second place. The given quantity in the third place.

The only items that enter into a ratio are the substance of which there is a stated amount and the substance of which the amount is desired.

Problems

634. How many grams of potassium chloride can be obtained from 1000 grams of potassium chlorate?

635. How many ounces of exsiccated ferrous sulphate may be manufactured from 25 av. ounces of crystallized ferrous sulphate, if six molecules of water are removed by heat?

636. How many lbs. of carbonic acid gas are lost when 50 lbs. of carbonate of lime are converted into oxide?

637. When crystallized sodium carbonate is exposed to dry air it loses half of its water of crystallization. How many ounces of effloresced sodium carbonate may be obtained from 5 ounces of the crystallized carbonate?

638. How many grams of mercury in one fourth pound of corrosive sublimate?

639. How many grams of mercury in one fourth pound of calomel?

640. How many grains of iodine in one ounce of potassium iodide?

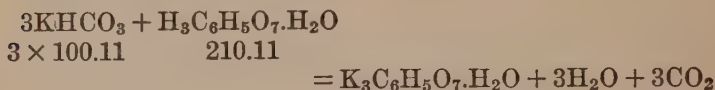
641. How much anhydrous magnesium sulphate can be made from 100 grams of the crystallized salt?

642. How many grains of the free alkaloid morphine can be obtained from 10 grams of the sulphate?

78. To Find the Amount of One Substance Required to Unite with a Given Quantity of Another

When working problems that involve chemical action, it is advisable to first write an equation that completely expresses the chemical action and the exact amount of each substance represented in the equation. This will prevent overlooking cases where more than one molecule of a substance unites with only one molecule of another. In many cases water is in actual combination with a substance, and must not be neglected when it forms a part of one or both terms of a problem, as in the case of citric acid in the problem given below.

643. Example. *How many grains of citric acid are required to unite with 2 drams of potassium bicarbonate to form potassium citrate?*



As three molecules of potassium bicarbonate are required to unite with one molecule of citric acid, the number of grains of potassium bicarbonate required to unite with 210.11 grains of citric acid is three times its molecular weight, or 300.33 grains. If 300.33 grains of potassium bicarbonate require 210.11 grains of citric acid, one grain will require $\frac{1}{300.33}$ of 210.11, or 0.6995 of one grain. Then 2 drams or 120 grains will require 120×0.6995 , or 83.940 grains of citric acid.

Or if 300.33 grains of potassium bicarbonate required 210.11 grains of citric acid, 120 grains will require x grains.

Or

$300.33 : 210.11 :: 120 : x, x = 83.94$ grains of $\text{H}_3\text{C}_6\text{H}_5\text{O}_7 \cdot \text{H}_2\text{O}$

Problems

644. How many grams of sodium bicarbonate are required to unite with 600 grams of absolute sulphuric acid?

645. If hydrogen sulphide is passed into a solution containing 50 grams of lead acetate, how many grams of the gas will be consumed in the precipitation of the lead as sulphide?

646. Find the number of grains of hydrochloric acid gas that will be required to unite with an apothecaries ounce of potassium bicarbonate.

647. Find the number of grains of salicylic acid which must be mixed with 4 drams of sodium bicarbonate to form sodium salicylate.

648. Find the number of grams of ammonium carbonate re-

quired to combine with 200 grams of citric acid to form ammonium citrate.

649. How many grams of iodine are required to unite with 60 grams of iron to form ferrous iodide?

650. How many grams of iron are consumed in the manufacture of ferrous iodide from 75 grams of iodine?

651. How many grams of potassium iodide are required to unite with 331 grams of mercuric chloride to form mercuric iodide?

652. How many grams of mercury may be dissolved in strong nitric acid, which contains 25 grams of absolute acid? The solution is to be made without heat.

653. How many grains of absolute hydrochloric acid are required to dissolve 3 drams of mercuric oxide?

654. If 100 grams of granular effervescent lithium citrate contain 57 grams of sodium bicarbonate and 30 grams of tartaric acid, how many grams of citric acid must be added to combine with the excess of the sodium bicarbonate?

655. One hundred grams of effervescent salt contain 25 grams of citric acid and 20 grams of tartaric acid. How many grams of sodium bicarbonate must it contain to combine with both acids?

79. To Find the Amount of Substance Required to Make a Given Quantity of Product

656. *Example.* How many grams of silver will be required to make 18 grams of silver nitrate?

$\text{AgNO}_3 : \text{Ag} :: 18 : x$

169.89 : 107.88 :: 18 : 11.43, the amount of silver required

Problems

657. How many ounces of metallic iron, assuming the iron to be pure, will be required to make 32 ounces of crystallized ferrous sulphate?

658. How many grains of magnesium oxide will be required to make 450 grains of magnesium sulphate?

659. How many grams of pure metallic zinc must be dissolved in hydrochloric acid to make 1500 grams of zinc chloride?

660. How many grams of iodine will be consumed in the manufacture of a kilogram of lead iodide?

661. How many grains of bromine are there in an apothecaries ounce of ferrous bromide?

662. How many grams each of pure calcium oxide and hydrochloric acid gas are required to manufacture 500 grams of crystallized calcium chloride?

663. How many ounces of alum will be required to make one fourth of a pound of exsiccated alum?

664. How many grams of sulphate of iron must be used in the manufacture of 6 ounces of exsiccated sulphate of iron?

665. How much ammonium chloride will be required to furnish the following quantities of 10 per cent. ammonia water: (a) 90 grams; (b) 60 cc.; (c) 4 av. oz.; (d) 6 fluidounces?

666. How much mercury will be required to form the following quantities of mercuric oxide: (a) 30 oz.; (b) 60 grams; (c) 2 dekagrams?

80. To Find the Amount of Material Formed from a Given Quantity of Substance

667. **Example.** *How many grams of calomel will be formed by treating 100 grams of corrosive sublimate with an excess of mercury?*



271.52 : 472.12 : : 100 : 173.88 Gm. of HgCl

Problems

668. How many grams of mercuric chloride can be formed from 120 grams of mercury?

669. How many grains of barium carbonate will be formed by passing carbon dioxide through a solution containing 1000 grains of barium chloride?

670. If a solution containing 500 grams of silver nitrate is precipitated by hydrochloric acid, how much silver chloride will be formed? What quantity of silver does it contain?

671. If an excess of iron wire is acted upon by 45 grams of iodine, how many grams of ferrous iodide will be formed?

672. How many ounces of exsiccated sulphate of iron can be prepared from one pound of crystallized sulphate of iron?

673. How many grams of silver nitrate can be made from one hectogram of silver?

674. How much carbon dioxide can be formed by the complete combustion of 30 grams of carbon?

675. How much ferric oxide will be formed by the complete oxidation of 12 grams of iron?

676. A chemist found by analysis 0.86 gram of barium sulphate. How much barium chloride did the sample contain?

677. In the analysis of a preparation 0.424 gram of silver chloride was obtained. How much silver nitrate did the preparation contain?

81. When the Given Quantity Is Not Absolute but of a Definite Strength

678. Example. *How many grams of sodium bicarbonate will be required to neutralize 150 grams of hydrochloric acid?*

Absolute hydrochloric acid is a gas, and is found in commerce only as a solution of the gas in water, of varying strength. In the problem the strength of the acid is not given; therefore, it must be considered as the strong pharmacopœial acid, which contains 31.9 per cent. by weight of acid. One hundred and fifty grams of hydrochloric acid contain 31.9 per cent. of 150, which is 47.85 Gm. of absolute HCl.



$$36.47 : 84.01 :: 47.85 : 110.225 \text{ Gm. of NaHCO}_3$$

Problems

679. How many grains of barium sulphate will be precipitated by treating 4 apothecaries ounces of dilute sulphuric acid with barium chloride?

680. How many ounces of pure potassium hydroxide may be neutralized by 100 ounces of 10 per cent. nitric acid?

681. How many grams of magnesium carbonate may be formed from 250 grams of a 30 per cent. solution of magnesium sulphate?

682. If an excess of zinc is treated with 12 avoirdupois ounces of hydrochloric acid, how many ounces of zinc chloride will be formed?

683. If 400 grains of sodium carbonate, which contain 75 per cent. of anhydrous sodium carbonate, be treated with salicylic acid, how many grains of sodium salicylate will be formed?

684. How many grams of ammonium chloride can be formed by neutralizing one pound of 10 per cent. ammonia water with hydrochloric acid?

685. If 25 grams of 93 per cent. sulphuric acid is neutralized with potassium hydroxide, how many grams of potassium sulphate will be formed?

686. When a kilogram of 10 per cent. hydrochloric acid is added to an excess of ammonia water, how many grams of ammonium chloride will be formed?

687. How many grams of zinc sulphate will be formed by the action of a kilo of 93 per cent. sulphuric acid on zinc? How many grams of hydrogen gas will be released by the reaction?

688. How much silver chloride can be formed by the precipitation from 0.5 of a gram of strong hydrochloric acid, with silver nitrate?

689. How many grams of silver nitrate will be required to precipitate 150 grams of 10 per cent. hydrobromic acid? And how many grams of silver bromide will be formed?

82. When the Desired Quantity Is to Be of a Certain Strength

690. *Example. How many grams of 10 per cent. hydrochloric acid will be required to precipitate the silver from a solution containing 12 grams of silver nitrate?*

In this case the per cent. does not refer to the substance of which the quantity is given, but to the required substance. The per cent. cannot be taken into consideration until the amount of absolute substance has been obtained. Therefore, in this problem the first step is to find the amount of absolute hydrochloric acid required and then divide by the per cent.

$$\begin{aligned} \text{AgNO}_3 : \text{HCl} \\ 169.89 : 36.47 : : 12 : 2.576 = \text{absolute HCl} \\ 2.576 \div 0.10 = 25.76 \end{aligned}$$

Problems

691. How many grams of 96 per cent. sulphuric acid will be required to precipitate 725 grams of lead sulphate from a solution of lead acetate?

692. How many ounces of 25 per cent. nitric acid will be required to neutralize 5 ounces of sodium bicarbonate?

693. How many grams of 15 per cent. solution of silver nitrate are required to precipitate silver iodide from a solution containing 80 grams of sodium iodide?

694. How many grams of 32 per cent. hydrochloric acid are required to liberate the carbon dioxide from 1575 grams of a 15 per cent. solution of potassium carbonate?

695. How many ounces of a solution containing 5 per cent. of barium chloride will be required to precipitate twenty-five ounces of a solution containing 20 per cent. of zinc sulphate?

696. How many grams of 10 per cent. hydrochloric acid will be required to precipitate 4.5 grams of silver nitrate?

697. How many cubic centimeters of 10 per cent. hydrobromic

acid will be required to form half a dram of silver bromide? How many grams of silver nitrate will be required?

698. How many cubic centimeters of 5 per cent. solution of sodium hydroxide will be required to neutralize 10 grams of glacial acetic acid?

699. How many grams of hydrochloric acid, 31 per cent., will be required to neutralize 150 grams of 28 per cent. ammonia water?

700. How many cubic centimeters of 10 per cent. sulphuric acid will be required to neutralize 75 cc. of 28 per cent. ammonia water?

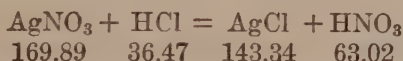
701. How many cubic centimeters of 5 per cent. sodium hydroxide will be required to neutralize 4 fl. oz. of 10 per cent. sulphuric acid?

VOLUMETRIC ANALYSIS

Volumetric analysis is the quantitative estimation of substances by means of solutions of known strength, the quantity of substance being determined by the volume of the standard solution used.

83. Volumetric Solutions

The strengths of volumetric solutions are based upon their combining power, compared with the valency of hydrogen.



Thus, 36.47 parts of hydrochloric acid will unite with 169.89 parts of silver nitrate. Therefore, if 36.47 grams of absolute hydrochloric acid are dissolved in a liter of water, and 169.89 grams of silver nitrate in another liter of water, and the two solutions are mixed, there will be just enough acid to precipitate all the silver. The same will be true if any number of cubic centimeters of one solution be mixed with an equal number of cubic centimeters of the other solution. If one liter of a solution contains 36.47 grams of hydrochloric acid, each cubic centimeter would contain $\frac{36.47}{1000}$ or 0.03647 gram, and would be equivalent to 0.16989 gram of silver nitrate, or to $\frac{1}{1000}$ of the combining weight, in grams, of any other substances with which it will unite, e.g., 0.05611 gram of potassium hydroxide. There are as many milligrams of the reagent in each cubic centimeter of any volumetric solution as the number of grams of the reagent contained in one liter of the solution.

A normal solution is one that contains the combining weight, expressed in grams, of the active reagent in one liter of the solution. The combining weight or valency of a substance must not be confounded with the molecular weight.

The Pharmacopœia defines a normal volumetric solution, N/1, as one that contains in 1 liter the molecular weight of the active reagent, expressed in grams, and reduced to the valency corresponding to one atom of replaceable hydrogen or its equivalent.

Hydrochloric acid contains one atom of replaceable hydrogen. Sodium hydroxide and sodium chloride each contain one atom of sodium capable of replacing one atom of hydrogen. Therefore, their normal solutions should contain, respectively, HCl, 36.47 Gm.; NaOH, 40.01 Gm.; and NaCl, 58.46 Gm., in one liter. Sulphuric and oxalic acids each contain 2 atoms of replaceable hydrogen. Therefore, one liter of N/1 H_2SO_4 , molecular weight 98.08, should contain 49.04 Gm. One liter of N/1 oxalic acid, $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$, mol. wt. 126.06, should contain 63.03 grams. Two molecules of potassium permanganate in oxidation give off 5 atoms of oxygen, which are equivalent to 10 atoms of hydrogen; therefore, one fifth of one molecule of potassium permanganate represents the number of grams for one liter of normal solution.

$$\frac{\text{KMnO}_4}{158.03} \div 5 = 31.606 \text{ Gm.}$$

Decinormal solutions are one tenth the strength of normal and are expressed as N/10. Centinormal solutions are one hundredth the strength of normal and expressed as N/100. Semi-normal solutions are one half the strength of normal and are expressed as N/2. The following strengths are sometimes used: Twice the strength of normal, 2/N; one twentieth normal, N/20; one fortieth normal, N/40; one fiftieth normal, N/50.

The Pharmacopœia gives complete directions for the

manufacture of volumetric solutions, and under each a list of articles with the amount of each article that is equivalent to one cubic centimeter of the volumetric solution.

84. To Find the Factor

Many volumetric solutions change on standing. When this has occurred, instead of bringing them back to their original strength, many prefer to ascertain their strength and make the necessary correction each time they are used.

702. Example. *On exposure to air a decinormal solution of potassium hydroxide has absorbed carbon dioxide until 10.5 cc. of the solution are required to neutralize 10 cc. of decinormal acid. What correction must be made for each cc. of solution used?*

$10 \div 10.5 = 0.952$. If 10.5 cc. were required instead of 10, then one cc. of the solution is equal to $\frac{10}{10.5}$, or 0.952 cc. Since one cc. of the solution is the equivalent of only 0.952 of one cc. of a standard solution, then whenever this solution is used, the number of cc. of the solution consumed must be multiplied by the factor 0.952.

Problems

703. What will be the factor of an acid solution if 10 cc. of a standard alkali solution neutralize 9.4 cc. of the acid solution?

704. What is the factor of sodium thiosulphate solution if 28 cc. are required to decolorize 25 cc. of standard iodine solution?

705. How many cc. of standard sulphuric acid are equivalent to 40 cc. of N/10 acid which has a factor of 1.062?

706. How many grams of silver nitrate in 25 cc. of N/1 solution having a factor of 0.975?

707. What is the factor for a solution of potassium hydroxide if 55 cc. of N/100 are required to neutralize 5 cc. of a standard N/10 acid?

708. How many grams of absolute hydrochloric acid in 45 cc. of N/20 acid having a factor of 1.02?

709. What is the factor for a volumetric solution of potassium hydroxide if 22.6 cc. of N/40 are required to neutralize 5 cc. of N/10 acid?

85. Adjustment of Volumetric Solutions

It is customary to prepare volumetric solutions stronger than required, then after testing them with a known standard, dilute to the required strength.

710. Example. *Twenty cubic centimeters of an approximate normal solution of hydrochloric acid require 23 cc. of standard potassium hydroxide solution to neutralize. How many cubic centimeters of water must be added to 800 cc. to bring it to normal?*

If 20 cubic centimeters require 23 cc., one cc. will require $\frac{1}{20}$ of 23, or 1.15 cubic centimeters, 800 cubic centimeters will require 800 times 1.15, or 920 cubic centimeters, the number of cubic centimeters to which the acid must be diluted to bring it to normal. $920 - 800 = 120$, the number of cubic centimeters of water that must be added.

Or by proportion:

$$20 : 23 :: 800 : 920 \text{ cc.}$$

Problems

711. Twenty-five cubic centimeters of an approximate solution of potassium hydroxide require 27.5 cc. of an N/10 solution of sulphuric acid to neutralize. To what volume must 1000 cc. be diluted to make an N/10 solution?

712. Twenty-five cubic centimeters of an approximate N/10 solution of sodium thiosulphate are decolorized by 27.2 cc. of N/10 iodine solution. To what volume must 900 cc. of the solution be diluted to make an N/10 solution?

713. To what volume must 950 cc. of approximate solution of potassium hydroxide be diluted to make an N/10 solution, if 45

cc. are required to neutralize 0.9407 Gm. of potassium bitartrate (the amount required for 50 cc. of standard solution)?

714. How many grams of water must be added to 875 cc. of an approximate solution of potassium sulphocyanate to make an N/10 solution, when 9.4 cc. are required to precipitate the silver from 10 cc. of N/10 silver nitrate solution, using ferric ammonium sulphate as indicator?

715. How many cubic centimeters of water must be added to 850 cc. of N/1 potassium hydroxide solution to make a normal solution, if 9.4 cc. are required to neutralize 0.63025 gram of oxalic acid, the equivalent of 10 cc. of normal solution?

716. To what volume must 1200 cc. of sodium chloride solution be diluted to make an N/10 solution, if 23.4 cc. are required to precipitate the silver from 25 cc. of N/10 silver nitrate solution?

86. Alkalimetry

717. Example. *What is the strength of caustic potassa when 0.5 Gm. neutralizes 8 cc. of N/1 acid?*

Since one cubic centimeter of normal acid will neutralize 0.05611 Gm. of potassium hydroxide, 8 cc. will neutralize 8 times 0.05611, or 0.44888 Gm. If half a gram of caustic potassa contains 0.44888 gram of potassium hydroxide, 100 grams will contain as many times 0.44888 gram as 0.5 is contained times in 100, or $0.44888 \times \frac{100}{0.5} = 89.776$ Gm., or 89.776 per cent.

Problems

718. How many grams of potassium hydroxide are there in 800 cc. of a solution, when 10 cc. of the solution require 25 cc. of normal acid to neutralize it?

719. What degree of purity has lithium carbonate if 0.5 gram of the dry salt, when dissolved in water, neutralizes 13.5 cc. of normal sulphuric acid, using methyl orange as indicator?

720. How many pounds of anhydrous sodium carbonate are present in 50 lbs. of commercial washing soda, if two grams,

when dissolved in water and titrated, using methyl orange as indicator, require 18 mls of N/1 sulphuric acid for neutralization?

721. A pharmacist had 100 pounds of commercial sodium carbonate that had previously lost part of its water of crystallization, so that when tested 1 Gm. neutralized 8 cc. of N/1 volumetric solution of sulphuric acid. What was its original weight?

722. How many grams of ammonia gas in 750 cc. of ammonia water, if 5 cc. require 30 cc. of N/1 sulphuric acid for neutralization?

723. What is the strength of sodium hydroxide, if 2 grams, when assayed, require 45 cc. of normal hydrochloric acid, having a factor of 0.96, to neutralize?

724. Three grams of potassium carbonate, when assayed, require 41 cc. of normal sulphuric acid, having a factor of 1.03. What is the strength of the carbonate?

725. A pharmacist bought a carboy of ammonia water, and after a few months, when assayed, 4.8 grams required 17.4 cc. of normal sulphuric acid to neutralize. What was the strength of the ammonia water?

87. Acidimetry

726. Example. *How many grams of absolute hydrochloric acid are there in 160 grams of acid if 5 grams of the solution require 40 cc. of normal potassium hydroxide for neutralization?*

Since one cubic centimeter of normal alkali will neutralize 0.03647 gram of hydrochloric acid, 40 cc. will neutralize 40 times 0.03647, or 1.4588 grams of HCl. If 5 grams of the acid contain 1.4588 grams, 160 grams will contain as many times 1.4588 grams as 5 is contained times in 160, or 1.4588 $\times \frac{160}{5}$ = 46.68 grams of absolute hydrochloric acid.

Problems

727. What is the strength of acetic acid when 30 cc. of normal potassium hydroxide are required to neutralize 5 grams of the acid?

728. When 4 grams of acetic acid neutralize 40 cc. of decinormal potassium hydroxide solution, what is the strength of the acid?

729. How many cubic centimeters of decinormal sulphuric acid are required to neutralize 50 grams of a 5 per cent. solution of potassium hydroxide?

730. How many grams of acid in 500 cc. of commercial hydrochloric acid if 2 cc. neutralize 17 cc. of normal potassium hydroxide solution, factor 0.952?

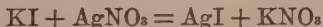
731. If 5 grams of aromatic sulphuric acid are mixed with water and boiled thoroughly, and when cold require 20 cc. of normal potassium hydroxide for neutralization, what is the strength of the acid?

732. Forty cubic centimeters of normal potassium hydroxide are required to neutralize 3 grams of tartaric acid. What is the strength of the acid?

88. Silver Nitrate Volumetric Solution

Problems

733. What per cent. of potassium iodide is present in commercial potassium iodide, when 0.5 Gm. requires 29.8 cc. of N/10 silver nitrate solution to produce a permanent red color when tested according to the Pharmacopœia?

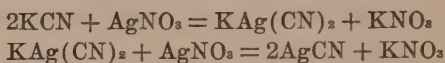


734. What is the strength of diluted hydrobromic acid, when 1 Gm. requires 12 cc. of N/10 silver nitrate to produce a permanent red tint with potassium chromate as indicator?

735. What is the strength of potassium cyanide when 0.5 Gm. of the commercial salt requires 70 cc. of N/10 silver nitrate solution for complete precipitation?

736. How many grams of pure potassium cyanide are there in 50 grams of the commercial salt if 1 gram requires 69 cc. of decinormal silver nitrate to produce a faint, permanent precipitate, when tested according to the Pharmacopœia?

Note. As the double cyanide of potassium and silver is formed, one molecule of silver nitrate is equivalent to two molecules of potassium cyanide. Therefore, one cc. of decinormal silver nitrate is equivalent to 0.01293 Gm. of potassium cyanide. Had the silver solution been added to complete precipitation it would have required 138 cc., for the double salt would have been broken up and silver cyanide formed as in problem 685. Thus:



737. What is the strength of dilute hydrocyanic acid if 2 cc. require 14.2 cc. of decinormal silver nitrate for complete precipitation?

738. What per cent. of hydrocyanic acid is present in fl. ext. of wild-cherry bark, when the distillate from 10 cc. is carried into 10 cc. of decinormal silver nitrate solution and 6.5 cc. of decinormal potassium sulphocyanide solution are required to precipitate the excess of silver nitrate?

Note. Volumetric solution of potassium sulphocyanide is only used in residual titration as in above problem. The silver nitrate must be present in excess, and a few drops of a solution of ferric nitrate added, then the excess of silver nitrate determined by adding the solution of sulphocyanide until a permanent reddish-brown tint is produced. Each cubic centimeter of the sulphocyanide is equivalent to one cubic centimeter of the silver nitrate solution.

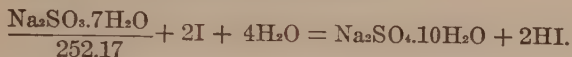
739. How many grains of ferrous iodide in one avoirdupois pound of syrup of iodide of iron if 1.536 grams of the syrup, when tested according to the Pharmacopœia, using 6 cc. of decinormal silver nitrate solution, require 0.5 cc. of decinormal sulphocyanide solution to produce a reddish-brown tint? Also, how many grains of syrup must be added to reduce it to the Pharmacopœial strength?

89. Iodine Volumetric Solution

Problems

740. If one gram of commercial sodium sulphite be added to 80 cc. of decinormal iodine solution and 5 cc. of N/10 sodium thio-

sulphate solution be required to discharge the color, what per cent. of pure sodium sulphite is present?



Note. As each molecule of sodium sulphite requires two molecules of iodine, each cubic centimeter of decinormal solution of iodine is equivalent to 0.012609 gram of sodium sulphite.

741. If 0.1 gram of arsenic trioxide decolorizes 19.5 cc. of decinormal iodine solution, what per cent. of pure arsenic trioxide is present?



742. What per cent. of sulphur dioxide is present in a solution of sulphurous acid when 2 Gm. diluted with water decolorize 38 cc. of N/10 iodine solution?

743. What is the strength of a solution of sodium thiosulphate when 10 cc. of the solution, containing a few drops of starch paste, require 45 cc. of N/10 iodine solution to produce a permanent blue color?

744. How many grams of arsenic trioxide are present in 1000 cc. of a solution if 5 cc. of the solution, when boiled with a mixture of sodium carbonate, a little starch and sufficient water to make 100 cc. followed by cooling, require 25 cc. of N/10 iodine solution to produce a permanent blue color?

90. Sodium Thiosulphate Volumetric Solution

Problems

745. If 0.5 Gm. of iodine requires 39 cc. of decinormal sodium thiosulphate solution to decolorize the iodine, what is the per cent. of pure iodine?

746. How many grams of iodine are present in 100 cc. of tincture of iodine if 6 cc. require 32 cc. of N/10 sodium thiosulphate solution to decolorize it?

747. If 0.5 gram of chlorinated lime requires 35.7 cc. of decinormal sodium thiosulphate solution to decolorize the iodine liberated from potassium iodide by the chlorine, what is the per cent. of available chlorine?

Note. This estimation is based on the fact that one atom of free chlorine liberates one atom of iodine from one of its salts.

748. If twenty-three cubic centimeters of N/10 sodium thiosulphate solution are required to decolorize the iodine liberated from potassium iodide by 20 grams of chlorine water, what is the per cent. of free chlorine?

749. If one gram of solution of iron tersulphate, when tested according to the Pharmacopœia, requires 14.2 cc. of decinormal sodium thiosulphate to decolorize the iodine liberated, what is the per cent. of iron in the solution?

Note. Two atoms of iodine are liberated in the reduction of two atoms of iron from the ferric to the ferrous condition, hence one cc. of decinormal iodine is equivalent to 0.005584 gram of iron.

750. Fifteen cubic centimeters of decinormal sodium thiosulphate are required to decolorize the iodine liberated when potassium iodide is treated with 0.5 Gm. of iron citrate as directed in the quantitative test for iron citrate. What per cent. of iron is present in the citrate?

91. Potassium Permanganate Volumetric Solution

Problems

751. If one gram of commercial ferrous sulphate requires 30 cc. of potassium permanganate solution to produce a pink tint, what per cent. of crystallized ferrous sulphate is present?

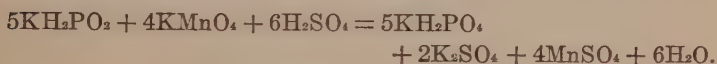
Note. Ten molecules of ferrous sulphate have been oxidized to ferric by two molecules of potassium permanganate; hence, one fifth of a molecule of potassium permanganate is equivalent to one molecule of ferrous sulphate.

752. How many grams of ferrous carbonate are there in 4 avoirdupois ounces of the saccharated ferrous carbonate if two

grams require 26 cc. of decinormal potassium permanganate to produce a pink color?

Note. The reaction is the same as in the last except that the sulphuric acid first converts the carbonate into a sulphate.

753. How many grams of pure potassium hypophosphite are there in 150 Gm. of the commercial salt if three cubic centimeters of decinormal oxalic acid are required to destroy the pink color left after treating 0.1 Gm. of the salt with 40 cc. of decinormal potassium permanganate solution?



Note. As each cubic centimeter of the oxalic acid solution is equivalent to one cubic centimeter of the potassium permanganate solution, 37 cc. of the permanganate solution will be consumed in the oxidation of the hypophosphite.

754. How many grams of hydrogen peroxide are there in 200 cc. of hydrogen peroxide solution if 1 cc. decolorizes 20 cc. of decinormal permanganate solution?

92. Alkaloidal Estimations

The volumetric estimation of alkaloids is based upon the fact that they unite with acids to form salts, and thus neutralize definite amounts of acids. The alkaloid is obtained as pure as possible and dissolved in an excess of standard acid, and the excess of acid determined by titration with a standard alkali, using hematoxylin, cochineal, or iodeosin as indicator. The difference between the standard acid taken and the standard alkali used represents the amount of acid combined with the alkaloid. Most alkaloids that are estimated volumetrically are monobasic; therefore, 1 cc. of decinormal acid is equivalent to 0.0001 of the molecular weight of the alkaloid expressed in grams. In case the alkaloid is dibasic the molecular weight should be divided by two and then by 0.0001 to obtain the equivalent of one cc. of acid.

755. Example. *If the morphine from 2 grams of opium is dissolved in 12 cc. of decinormal acid, and 29 cc. of centinormal alkali are required to neutralize the excess of acid, what is the per cent. of morphine in the opium?*

Twenty-nine cubic centimeters of N/100 alkali will neutralize 2.9 mls of N/10 acid. Subtracting 2.9 cc. from 12 cc. of acid taken will leave 9.1 cc. as the amount of acid combined with the morphine. The molecular weight of morphine is 303.26; therefore, 1 cc. of acid is equivalent to 0.030326 Gm. of morphine, and 9.1 cc. is equivalent to 0.27596 Gm., the amount from 2 Gm. of opium, which, multiplied by 50, will give the per cent., or 13.79 per cent.

Problems

756. The morphine from one gram of opium was dissolved in 5 cc. of decinormal acid and required 2 cc. of centinormal alkali to neutralize the excess of acid; what is the per cent. of morphine in the opium?

757. What is the purity of morphine if 0.1 Gm. when dissolved in 5 cc. of N/10 acid required 7.2 cc. of N/40 alkali to neutralize the excess of acid?

758. What is the per cent. of alkaloid in belladonna root when the alkaloid from 10 Gm. is dissolved in 3 cc. of N/10 sulphuric acid and requires 5.5 cc. of N/50 potassium hydroxide to neutralize the excess of acid?

Note. The molecular weights of the alkaloids of belladonna and stramonium are 289.2.

759. If the alkaloids from 10 grams of stramonium leaves are dissolved in 2 cc. of acid, N/10, and 11 cc. of N/100 alkali are required to neutralize the excess of acid, what is the per cent. of alkaloid?

760. Ten grams of coca are macerated in an alkaline mixture containing 100 cc. of a mixture of chloroform and ether. The alkaloid is removed from 50 cc. of the chloroform-ether solution and dissolved in 5.5 cc. of decinormal acid, and it requires 44.4 cc.

of centinormal alkali to neutralize the excess of acid. What is the per cent. of cocaine?

761. The impure morphine from 20 cc. of tincture of opium weighed 0.28 gram. One hundred milligrams of the morphine were dissolved in 5 cc. of N/10 acid and 7.6 cc. of N/40 alkali were required to neutralize the excess of acid. How many grams of morphine are there in 100 cc. of tincture?

762. Opium containing 30 per cent. of moisture is dried and the morphine from 2 grams of the powder combined with 9.8 cc. of decinormal acid. What per cent. of morphine did the original moist opium contain?

MEASUREMENTS OF GASES

93. Gases in General

Substances existing in the gaseous state are often measured and referred to by volume. Important problems arise as to the volume occupied by a given weight of gas, or the weight of a given volume of gas. Thus it becomes necessary to understand the relation existing between the volume and weight of gases.

The volume of all gases varies under different conditions of temperature and pressure. *A gas is said to be normal when the temperature is 0° C. and the atmospheric pressure is 760 millimeters.* In all calculations a gas is considered as normal unless otherwise stated.

The weight of a liter of air is 1.294 grams, oxygen 1.429 grams, and hydrogen 0.0897 gram.

Specific Gravity of Gases

The comparative weight of equal volumes of different substances is known as specific gravity. We have seen that, for solids and liquids, water is taken as the unit of comparison. For gases, air, oxygen or hydrogen serves the same purpose.

The specific gravity of gases is obtained by dividing the weight of a given volume of the gas by the weight of an equal volume of the gas to be used as the unit of comparison.

94. To Find the Specific Gravity of Gases as Compared with Air

763. Example. *One liter of sulphureted hydrogen weighs 1.52 grams. What is its specific gravity?*

The weight of a liter of air is 1.294 Gm. $1.52 \div 1.294 = 1.1746$, the sp. gr.

Problems

764. A cylinder holds 142.065 grams of air and 313.022 grams of sulphur dioxide. What is the specific gravity of the latter?

765. Twelve liters of ammonia gas weigh 9.13 grams. What is the sp. gr. of the ammonia?

766. What is the specific gravity of nitrogen if one liter weighs 1.252 grams?

767. What is the specific gravity of chlorine if two liters of the gas weigh 6.3239 grams?

95. To Change the Specific Gravity of Gases from Air as Unit to Hydrogen as Unit

768. Example. *The specific gravity of nitrous oxide gas as compared with air is 1.52. What is its specific gravity as compared with hydrogen?*

Since air is 14.4 heavier than hydrogen, the specific gravity of any gas as compared with hydrogen must be 14.4 greater than the specific gravity when compared with air.

$$1.52 \times 14.4 = 21.888$$

Problems

The specific gravities of the following gases were obtained with air as unit. What are their specific gravities with hydrogen as unit?

$$H = 1$$

769. Nitric oxide, 1.0344 sp. gr.

770. Hydrofluoric acid, 0.6905 sp. gr.

771. Sulphur dioxide, 2.206 sp. gr.

772. Ozone, 1.6535 sp. gr.

96. To Change the Specific Gravity of Gases from Air as Unit to Oxygen as Unit

773. Example. *What is the sp. gr. of nitrous oxide as compared with oxygen when its sp. gr. as compared with air is 1.52?*

Air weighs 0.9055 as much as oxygen. Therefore to change the specific gravity of a gas from air as unit to oxygen as unit it must be multiplied by 0.9055. $1.52 \times 0.9055 = 1.3763$, the sp. gr. with oxygen as unit.

Problems

If the specific gravities of the following gases are those with air as the unit, what will be their specific gravities with oxygen as unit?

774. Methane, sp. gr. 0.551.

775. Carbon dioxide, sp. gr. 1.515.

776. Ethyl nitrate, sp. gr. 2.585.

97. To Find the Specific Gravity of Gases with Hydrogen as Unit

One liter of hydrogen weighs 0.08987 gram and is called a Crith.

777. Example. One liter of oxygen weighs 1.429 Gm. What is its specific gravity?

$$1.429 \div 0.08987 = 15.89, \text{ sp. gr. of oxygen.}$$

Problems

778. What is the specific gravity of ammonia gas one liter of which weighs 0.7608 gram?

779. Ten liters of the vapors of iodine weigh 113.15 grams. What is its specific gravity?

780. Five liters of nitrous oxide gas weigh 9.828 grams. What is its specific gravity?

781. What is the specific gravity of methane if four liters weigh 2.858 grams?

98. To Change the Specific Gravity of Gases from Hydrogen as Unit to Air as Unit

782. Example. What is the specific gravity of ammonia gas compared with air?

Its specific gravity compared with hydrogen is 8.464. As this is the opposite of section 90, we divide by 14.4 or multiply by its reciprocal, which is 0.0694.

Thus, $8.464 \div 14.4$, or $8.464 \times 0.0694 = 0.587$, the sp. gr. of ammonia gas as compared with air.

Problems

The specific gravities of the following gases are given with hydrogen as unit. What are their specific gravities with air as unit?

783. Arsine, 38.725.

784. Methane, 7.95.

785. Carbon dioxide, 21.83.

786. Ethyl nitrite, 37.245.

99. To Change the Specific Gravity of Gases from Hydrogen as Unit to Oxygen as Unit

787. Example. *What is the sp. gr. of ammonia gas with oxygen as unit, when its sp. gr. with hydrogen as unit is 8.465?*

As oxygen is 15.88 heavier than hydrogen, the sp. gr. of a gas, when compared with oxygen, would be as much less, when compared with hydrogen, as 15.88 is contained in its sp. gr. with hydrogen as unit.

Thus, $8.465 \div 15.88 = 0.533$, the sp. gr. of ammonia gas as compared with oxygen.

Problems

Change the following specific gravities with hydrogen as unit to specific gravities with oxygen as unit.

788. Ammonia gas, sp. gr. 8.465.

789. Chlorine, sp. gr. 35.18.

790. Sulphur dioxide, sp. gr. 31.795.

791. Carbon dioxide, sp. gr. 21.74.

100. To Find the Specific Gravity of Gases with Oxygen as Unit

Divide the weight of a given volume of the gas by the weight of an equal volume of oxygen, or divide the weight of a liter of the gas by the weight of a liter of oxygen, which is 1.429.

792. Example. *One liter of acetylene weighs 1.1708 grams. What is its sp. gr. compared with oxygen?*

$$1.1708 \div 1.429 = 0.8186 \text{ sp. gr. of acetylene.}$$

Problems

793. The weight of a liter of nitrogen is 1.247 Gm. What is its specific gravity compared with oxygen?

794. The weight of three liters of ethyl nitrite gas is 10.04 Gm. What is its specific gravity?

795. Methane is 7.95 times heavier than hydrogen. What is its specific gravity compared with oxygen?

796. A liter of nitric oxide weighs 1.349 Gm. What is its specific gravity?

101. To Change the Specific Gravity of Gases from Oxygen as Unit to Hydrogen as Unit

797. Example. *The sp. gr. of nitrogen, with oxygen as one, is 1.429. What is its sp. gr. with hydrogen as one?*

Since oxygen is 15.88 heavier than hydrogen, the specific gravity of any gas as compared with hydrogen must be 15.88 times greater than the specific gravity when compared with oxygen.

$$1.429 \times 15.88 = 22.69, \text{ the sp. gr. of nitrogen.}$$

Problems

The following specific gravities are with oxygen as unit. What will be their specific gravities with hydrogen as unit?

798. Chlorine, sp. gr. 2.216.

799. Hydrogen sulphide, sp. gr. 1.062.

800. Ozone, sp. gr. 1.5.

102. To Change the Specific Gravity of Gases from Oxygen as Unit to Air as Unit

801. Example. *The specific gravity of nitrous oxide with oxygen as unit is 1.375. What is its specific gravity with air as unit?*

Since oxygen is 1.1053 heavier than air, the specific gravity of any gas, compared with air, must be 1.1053 times greater than the specific gravity when compared with oxygen. Therefore to change specific gravity from oxygen as unit to air as unit multiply by 1.1053.

$1.375 \times 1.1053 = 1.5197$, the sp. gr. of nitrous oxide with air as one.

Problems

The specific gravities of the following gases are with oxygen as unit. What will be their specific gravities with air as unit?

802. Arsine, sp. gr. 2.436.

803. Phosphine, sp. gr. 1.063.

804. Hydrochloric acid gas, sp. gr. 1.14.

103. The Relation of Molecular Weight to Specific Gravity as Compared with Oxygen

As all molecules of gases are of the same volume, under like conditions of temperature and pressure, and molecular weights of gases are the relative weights of equal volumes compared with oxygen, it follows that the ratio of the molecular weights of two gases is the same as the ratio of their specific gravities.

Mol. wt.		Mol. wt.		sp. gr.		sp. gr.
of CO ₂	:	of NO ₂	::	of CO ₂	:	of NO ₂
44	:	46.008	::	1.375	:	1.4377

Therefore the molecular weight of oxygen is to the molecular weight of a gas as 1 is to the specific gravity of the gas. Hence, to find the specific gravity of a gas from its molecular weight, divide its molecular weight by 32, the molecular weight of oxygen. The product will be its specific gravity.

The molecular weight of carbon dioxide is 44, which divided by 32 gives 1.375 as its specific gravity.

Problems

Find the specific gravities of the following from their molecular weights:

- 805. Nitrogen.
- 806. Ammonia gas.
- 807. Ethyl nitrite.
- 808. Chlorine.
- 809. Sulphur dioxide.
- 810. Nitrous oxide.

104. To Find the Weight of a Given Volume of Gas

In the following problems in this work oxygen will be understood as the standard unit unless otherwise stated.

811. Example. *What is the weight of 25 liters of chlorine?*

Since the weight of a liter of oxygen is 1.429 grams, the weight of a given volume of any gas may be found by multiplying 1.429 by the specific gravity of the gas, and by its volume,

$$1.429 \times 2.216 \times 25 = 79.16.$$

Problems

- 812. How many grams in 450 liters of sulphur dioxide?
- 813. If the specific gravity of bromine vapor is 79.34, what will 75 liters weigh?

814. How many grams of arsine are required to fill a five-liter flask?

815. How many grams of nitrous oxide gas are required to fill a 10-gallon cylinder?

816. How many grams of nitrous oxide gas are required to fill a 25-liter cylinder? Sp. gr. of N_2O is 1.518 when air = 1.

105. To Find the Volume of a Given Weight of Gas

817. *Example.* What is the volume of 79.5 grams of chlorine?

$$\frac{79.5}{1.429 \times 2.216} = 25.11 \text{ liters.}$$

Problems

818. How large a flask will be required to hold 30 grams of sulphur dioxide?

819. How many liters in 480 grams of oxygen?

820. How many liters must a tank contain in order to hold 50 grams of sulphuretted hydrogen?

821. How many liters of oxygen can be obtained from 100 grams of potassium chlorate?

822. How many liters of carbon dioxide can be liberated from 150 grams of calcium carbonate?

823. How many liters of hydrogen will be consumed in the manufacture of reduced iron from 5 grams of ferric oxide?

106. To Find the Specific Gravity of a Mixture of Gases when the Composition and Quantity of Each Are Known

824. *Example.* If two liters of carbon dioxide are mixed with eight liters of nitrogen, what is the specific gravity of the mixture?

From the molecular formula of each we find the specific gravity; then multiply the specific gravity of each by its volume. The sum of the products divided by the total

volume of the mixture will give the specific gravity of the mixture.

Sp. gr. of carbon dioxide	$1.376 \times 2 = 2.752$
“ “ “ nitrogen “	$0.875 \times 8 = 7.$
	10 9.752

$9.752 \div 10 = 0.9752$, the sp. gr. of the mixture.

Problems

825. What is the specific gravity of a mixture containing 2 volumes of carbon dioxide, 3 volumes of oxygen, and 12 volumes of nitrogen?

826. What is the specific gravity of a mixture of 4 pints of nitrous oxide (N_2O) and one pint of nitric oxide (NO)?

827. If two liters of nitrous oxide are mixed with 5 liters of air, what will be the specific gravity of the mixture?

828. One liter of air, 500 cc. of hydrogen, 250 cc. of carbon dioxide, and 125 cc. of arsine are mixed. What is the specific gravity of the mixture?

829. Four volumes of ammonia gas and three volumes of hydrogen are mixed with two volumes of air. What is the resulting specific gravity?

107. Specific Volume of Gases

Specific volume of gases is the relative volume of equal weights of different gases. Specific volume is usually expressed in terms of cubic centimeters and may be defined as the number of cubic centimeters occupied by one gram of gas. Hence the specific volume of hydrogen is one divided by the weight of one cubic centimeter of hydrogen.

Thus, $\frac{1}{0.00008987} = 11126$ cc. The specific volume of air is $\frac{1}{0.001294} = 772.72$ cc.

Problems

What is the specific volume of the following:

830. Hydrochloric acid?

831. Chlorine?

832. Sulphur dioxide?

833. Oxygen?

834. Nitric oxide (NO)?

835. Methane (CH₄)?

108. Gram-Molecular Volume

A gram-molecule is the molecular weight of a substance expressed in grams. Therefore a gram-molecule of chlorine is 70.92, of carbon dioxide 44, of hydrogen 2.016 etc. grams.

A gram-molecular volume is the volume occupied by a gram-molecule of a gas. The normal volume is approximately 22.4 liters and is the same for all gases under like conditions. Owing to the large number of decimal places used the results vary slightly.

The gram-molecular volume may be obtained by dividing the gram-molecule by the weight of a liter of the gas.

836. Example. *What is the gram-molecular volume of carbon dioxide?*

The molecular weight of carbon dioxide is 44. Hence 44 divided by 1.9465, the weight of a liter of carbon dioxide, will give its gram-molecular volume.

Thus, $\frac{44}{1.9645} = 22.3975$, the gram-molecular volume of carbon dioxide.

Problems

Prove that the gram-molecular volume of the following is approximately 22.4 liters:

837. Hydrogen. 840. Chlorine. 843. Ammonia gas.

838. Oxygen. 841. Nitric oxide. 844. Sulphur dioxide.

839. Methane. 842. Phosphine. 845. Acetylene.

The gram molecule is sometimes used in the calculation of gaseous volumes, but the methods given in sections 105 and 106 are preferred by many.

109. To Find the Weight of a Given Volume of Gas, Using the Gram-Molecule

A given number of liters of a gas divided by the gram-molecular volume, 22.4, will give the number of gram-molecules in the given volume which multiplied by the molecular weight of the gas will give the weight of the given volume of gas.

846. Example. *How many grams in 25 liters of chlorine?*

$$\frac{25}{22.4} = 1.116 \text{ gram-molecules of Cl in 25 liters of the gas.}$$

$1.116 \times 70.92 = 79.146$, the weight of 25 liters of chlorine

The number of gram-molecules may be found by dividing 25 by 22.39, which gives 1.1165; this multiplied by 70.92, the molecular weight of chlorine, gives 79.18218 as the number of grams in 25 liters.

Problems

Work those given under section 105, using the gram-molecule.

110. To Find the Volume of a Given Weight of Gas, Using the Gram-Molecule

847. Example. *How many liters in 212.76 grams of chlorine?*

The weight of a gram-molecule of chlorine is 70.92 Gm. By dividing 212.76 by 70.92 we have 3 as the number of gram-molecules in 212.76 Gm. of chlorine. Three times 22.4, or 67.2 liters, is the volume of the chlorine.

Problems

Solve those given under section 100, using the gram-molecule.

VOLUMETRIC COMBINATION AND DECOMPOSITION OF GASES

111. To Find the Volume of a Gas that Will Unite with a Given Volume of Another Gas

Avogadro proved that under the same conditions of temperature and pressure equal volumes of all gases contained the same number of molecules. It therefore follows that the reverse of this is true. That is: All molecules in the form of gas, under normal conditions, occupy the same volume.

Therefore, for the purpose of illustration we may use the term volume in place of molecule.

Thus:

One vol. of H + 1 vol. of Cl = 1 vol. of HCl. $2\text{H} + 2\text{Cl} = 2\text{HCl}$.

Two vol. of H + 1 vol. of O = 2 vol. of H_2O . $2\text{H}_2 + 2\text{O} = 2\text{H}_2\text{O}$.

Three vol. of H + 1 vol. of N = 2 vol. of NH_3 . $3\text{H}_2 + 2\text{N} = 2\text{NH}_3$.

Gay-Lussac discovered that gases always combined in volumes having a simple ratio and that the volume of the product had a simple ratio to the volume of the reacting gases.

848. Example. *How many liters of hydrogen will be required to unite with 6 liters of oxygen?*

In the equation $\text{H}_2 + \text{O} = \text{H}_2\text{O}$ the ratio of oxygen to hydrogen is 1 : 2. Hence 1 : 2 :: 6 : 12. Therefore 12 is the number of liters of hydrogen required to unite with 6 liters of oxygen.

Problems

849. How many liters of arsine can be produced by combining four liters of hydrogen with arsenic?

The ratio of hydrogen to arsine is 3:2, $3\text{H}_2 + 2\text{As} = 2\text{AsH}_3$. Hence 3:2::4:2.666.

850. If 25 liters of air contain four fifths nitrogen and it could all be converted into ammonia gas, how many liters would be formed?

851. How many liters of water vapor will be formed in the manufacture of reduced iron from 5 liters of hydrogen and ferric oxide?

852. How many liters of hydrogen are required to manufacture a kiloliter of phosphine?

853. How many pints of hydrogen and oxygen will unite in order to form 5 gallons of vapor of water?

854. How many pints of oxygen will be consumed by burning sulphur to form a gallon of sulphur dioxide, and how many grains of sulphur will be consumed?

855. How many liters of hydrogen and chlorine must be united to form 15 liters of hydrochloric acid gas?

112. The Effect of Temperature and Pressure upon the Volume of Gases

In many operations gases must be measured at ordinary working temperature and pressure, and, as the volume of a gas varies with each variation of temperature or pressure, a correction must be made for both before we can ascertain its normal volume or its exact weight.

The volume of a gas or vapor is proportional to the pressure it sustains if the temperature remains the same.

113. Correction in Volume of Gases for Change in Pressure

Boyle's Law. If the pressure is doubled, the volume of the gas will be diminished one half. If the pressure be diminished one half, the volume will be doubled. The product obtained by multiplying the volume of the gas by

its pressure is always the same regardless of the pressure it sustains. For example, 50 liters of gas are measured at 600 millimeters pressure; $50 \times 600 = 30000$. Increase the pressure to 1200 millimeters and the volume is decreased to 25 liters; $25 \times 1200 = 30000$. This being true, if the volume and pressure of a gas be given and the pressure be increased or diminished, and the change in pressure given, the volume may be found.

856. Example. *If 30 liters of gas were measured at 400 millimeters pressure and the pressure increased to 800 millimeters, what would be its volume?*

$800 : 400 :: 30 : x$, $x = 15$ liters, the volume of the gas at 800 millimeters pressure.

Or if the volume is given to find the change in pressure, we have:

$$15 : 30 :: 400 : x, x = 800 \text{ millimeters.}$$

Problems

857. The volume of gas is 90 liters at 750 millimeters pressure. What will be its volume at 1000 millimeters pressure?

858. What will be the volume of 25 liters of oxygen at normal pressure when submitted to 850 millimeters pressure?

For normal pressure and temperature of gases see sec. 88.

859. At 900 millimeters pressure a volume of gas is 125 liters. What pressure will be required to increase its volume to 150 liters?

860. What will be the volume of a gas at 1250 mm. pressure if its volume is 200 liters at 850 mm. pressure?

861. Five volumes of sulphur dioxide are measured at 750 millimeters pressure. What will be its volume at 900 millimeters pressure?

862. One hundred cubic centimeters of nitrous oxide gas are measured at 780 millimeters pressure. How many cubic centimeters will it occupy at normal pressure?

863. What will be the weight of 1000 cubic centimeters of oxygen at a pressure of 900 millimeters?

864. What will be the volume of 10 grams of sulphur dioxide at a pressure of 500 millimeters?

865. How many grams of potassium chlorate will be required to fill a 10-gallon tank with oxygen at a pressure of 735 millimeters?

114. Correction in Volume of Gases for Changes in Temperature

All gases expand and contract equally for each degree of change in temperature, the pressure remaining constant.

Charles' Law. If 273 volumes of gas at 0° C. are heated they increase one volume for each degree. At 10° it will have increased 10 volumes and have become 283 volumes. The same volume when decreased in temperature from 0° C. to -25° C. will have decreased 25 volumes and have become 248 volumes. If 273 volumes increase or decrease one volume for each degree of change in temperature, then one volume will increase or decrease $\frac{1}{273}$ of its volume for each degree of change in temperature. Expressed decimally this equals 0.003663 of a volume.

866. Example. *If 500 cc. of gas are measured at 15° C. and then heated to 25° C., what is its volume?*

Since 273 volumes, when raised to 15° C., become 288 volumes, and the same volume when raised to 25° C. has become 298 volumes, and if 288 volumes have increased to 298 volumes in passing from 15° C. to 25° C., then one volume will have increased to $\frac{298}{288} = 1.03472$ volumes. If one volume increases to 1.03472 volumes, 500 volumes will increase to $500 \times 1.03472 = 517.36$ volumes. Hence we have

$$\frac{273 + 25}{273 + 15} = \frac{298}{288} \times 500 = 517.36 \text{ volumes.}$$

Problems

867. If 500 volumes of gas are measured at 0° C., what will be its volume at 25° C.?

868. Two hundred and fifty cubic centimeters of oxygen are measured at 15° C. and raised to 35° C.; what will be its volume?

869. If 1000 cubic centimeters of gas are measured at 40° C. and the temperature reduced to 10° C., what will be its volume?

870. A gas measures 10 liters at 40° C.; what will be its volume at 0° C.?

871. What will be the volume of a gas at -12° C. if it measures 125 volumes at -8° C.?

872. What will be the volume of a gas at -15° C. if it measures 250 volumes at 20° C.?

873. If one volume of gas is measured at -10° C., what will be its volume at 25° C.?

115. Correction in Volume of Gases for Changes in Temperature and Pressure

874. **Example.** *If 250 cc. of oxygen are measured at 10° C. and 760 millimeters pressure, what will be its volume at 30° C. and 775 millimeters pressure?*

As we have to correct for both temperature and pressure, we must necessarily combine sections 113 and 114.

$$\frac{250 \times 760 \times (273 + 30)}{775 \times (273 + 10)} = \frac{250 \times 760 \times 303}{775 \times 283} = 262.498 \text{ cc.}$$

Problems

875. What will be the volume of a gas at normal pressure and temperature which measured 750 cc. at 16° C. and 725 millimeters pressure?

876. If spirit of nitrous ether, when tested at 20° C. and 740 millimeters pressure, yields 50 cc. of nitric oxide gas, how many cc. of gas would have been produced had the test been made at 25° C. and normal pressure?

877. Twenty volumes of carbon dioxide, at normal tempera-

ture and pressure, are heated to 200° C. at a pressure of 850 millimeters. What is its volume?

878. If air is measured at 25° C. and normal pressure, what will be its volume when submitted to a pressure of 1500 millimeters and a temperature of -17° C.?

879. If 4455 cc. of vapor are measured at normal pressure and temperature of 27° C., what will be its volume at 15° C. and 745 millimeters pressure?

880. If 231 cubic inches * of nitrous oxide gas are measured at 31 inches pressure, what will be its volume at 25 inches?

881. A volume of gas measures 31 gallons at 36 inches pressure. What pressure will be required to increase its volume to 35 gallons?

882. A volume of sulphur dioxide measures 5 liters at 29.5 inches, what will be its volume at 900 millimeters pressure?

883. Fifty gallons of sulphur dioxide were measured at 750 millimeters pressure, what will be its volume at 36 inches pressure?

884. If 75 fluidounces of a gas are measured at 0° C., how many liters would it measure at 77° F.?

885. If 2500 cc. of a gas are measured at 60° F. and are raised to 35° C., what will be its volume?

886. If 4 pints of oxygen are measured at 100° F., what will be its volume at 0° C.?

887. How many cubic feet of carbon dioxide will 40 grams measure at 104° F. and what will be its volume if the temperature is reduced to 50° F.?

888. What will be the volume of nitrogen at -12° C. if it measures 4 pints at 8° F.?

889. If 10 liters of gas are measured at -9.4° F., what will it measure at 80° F.?

890. How many grains in 100 liters of nitrogen, measured at a pressure of 36 inches? What will be its volume at a pressure of 28 inches?

891. What will be the volume of a gas at normal temperature

*One inch is equal to 25.4 millimeters.

and pressure which measures 240 oz. at 60° F. and 27 inches pressure?

892. If spirit of nitrous ether, when tested at 68° F. and 24 inches pressure, yields 50 cc. of nitrogen dioxide, how many cubic centimeters will it produce had the gas been measured at normal temperature and pressure?

893. Fifty volumes of gas at normal temperature and pressure are heated to 392° F., at a pressure of 35 inches. What is its volume?

894. If 75 liters of air are measured at 77° F. and 30 inches pressure, what will be its volume when submitted to a temperature of 14° F. and a pressure of 36 inches?

895. What will be the weight of 75 cubic feet of oxygen when measured at 31 inches and a temperature of 85° F.?

896. What will be the weight of 60 liters of hydrocyanic acid gas if measured at 72° F. and 28 inches pressure?

897. What will be the volume of 40 grams of sulphur dioxide if measured at 65° F. and 26 inches pressure?

116. To Find the Volume of a Cylindrical Vessel

898. Example. *How many cubic inches in a vessel six inches in diameter and ten inches high?*

Since the radius is half the diameter, or 3, the square of the radius is 9, which multiplied by 3.1416 gives the area of the base, and this multiplied by the altitude, 10, gives the volume of the vessel, or 282.744 cubic inches.

Problems

899. How many cubic inches in a can five inches in diameter and nine inches high?

900. How many liters in a bottle 160 millimeters in diameter and 3 decimeters high?

901. How many gallons in a tank 5 feet high and 2 feet 6 inches in diameter?

902. How many pounds of mercury will a cylinder hold if its inner measure is 4 inches in diameter and 10 inches high?

903. How many pounds of glycerin will a can hold that is 18 inches high and 9 inches in diameter?

117. To Find the Volume of a Cone

904. Example. *What will be the capacity, in cubic centimeters, of a cone whose base is 16 centimeters in diameter and its altitude 30 centimeters?*

The area of the base is found, as in section 116, to be 201.0624 square centimeters. If we multiply this by one third the altitude we have 2010.624 mils as the contents of the cone.

Problems

905. How many cubic centimeters will a funnel hold that is 13.75 centimeters deep and 15 centimeters in diameter?

906. How many cubic inches in a hopper if the top is 16 inches in diameter and the depth 22 inches?

907. How many fluidounces in a cone-shaped can if the diameter of the base is 8 inches and the altitude 15 inches?

908. How many fluidounces will a can hold if the diameter is 8 inches and the total height 18 inches, the cone-shaped top one third of the height?

909. What is the capacity of a can whose diameter is 7 inches and the altitude of the cylinder $8\frac{1}{2}$ inches and that of the cone one and a half inches?

910. What is the capacity of a folded filter if the diameter of the filter is 25 centimeters?

911. A gasoline can is 23 inches in diameter and 26 inches high. How many gallons will it hold?

912. How many cubic centimeters are there in a can that is 15 inches high and 12 inches in diameter?

913. How many fluidounces are there in a can that is 15 centimeters high and 10 centimeters in diameter?

914. If a can is 32 centimeters in diameter and 36 centimeters high, how many pounds of glycerin will it hold?

915. How many pounds of mercury will a flask hold that is 8 centimeters in diameter and 20 centimeters high?

916. If a can is 12 inches in diameter, 16 inches high, and has a cone top that is 8 inches high, how many liters will it hold?

917. If you wish to have a round can made that will hold 50 gallons, what must be its dimensions?

918. What must be the diameter of a can that will hold 40 gallons if the height is 50 centimeters?

919. If a round can is to hold 120 gallons, what must the height be if the diameter is 85 centimeters?

920. What is the capacity of a can that is 35 centimeters long, 20 centimeters wide, 12 centimeters deep, square at one end and a half circle at the other?

118. Problems Based on the Tables of the Pharmacopœia

The main object in giving these problems is to help students to become familiar with the tables of the Pharmacopœia.

Answers to all of the problems in this section may be found in the tables of the Pharmacopœia. However, it is good practice to solve the problems first and then compare the answers thus obtained with those found in the tables.

In most cases a direct answer may be found, as in the following:

921. Example. *How many minims in eight cubic centimeters?*

On page 630 in column 5 we find under cubic centimeters 8, and opposite in column 6 we find 129.8 minims.

In some cases the exact answer cannot be found, and it may be necessary to make a slight calculation, as in the following:

922. Example. *How many grains in 565 milligrams?*

We cannot find 565 milligrams on page 631, but in the second column we do find 0.5 gram, which is 500 milligrams, and in the first column we find its equivalent to be 7.72 grains. In the fourth column we find 0.065 gram,

which is 65 milligrams, and opposite we find its equivalent which is 1 grain. By adding 1 to 7.72 we have 8.72 as the number of grains in 565 milligrams.

Problems

923. Reduce 600 Gm. to apothecaries ounces and grains.
924. Reduce 500 Gm. to fluidounces and minims.
925. How many Gm. in 27 fluidounces and 24.5 minims?
926. How many avoirdupois ounces in 396.893 grams?
927. How many avoirdupois ounces in 200 grams?
928. How many milligrams in 50 grains?
929. How many grains in 0.972 milligram?
930. How many minims in 12 cc.?
931. What is the specific volume of a liquid having a specific gravity of 0.920?
932. What is the volume in liters of a kilogram of a liquid having a specific gravity of 0.75?
933. What is the avoirdupois weight of 100 fluidounces of a liquid having a specific gravity of 1.16?
934. What is the volume in gallons of 100 lbs. of a liquid having a specific gravity of 1.000?
935. How many fluidounces in 1000 grains of liquid having a specific volume of 0.7576?
936. How many apothecaries ounces in 100 fluidounces of a liquid having a specific volume of 0.5435?
937. How many fluidounces in 100 avoirdupois ounces of a liquid having a specific gravity of 1.84?
938. How many fluidounces in 10 lbs. of U. S. P. hydrochloric acid?
939. How many fluidounces in 8 avoirdupois ounces of U. S. P. chloroform?
940. If a 50 Gm. pycnometer is standardized at 25° C. and is found to hold 52.165 grams of acetic acid, weighed at 20° C. what will be the per cent. of absolute acetic acid?
941. If a pycnometer holds 25 grams of water at 25° C., and

26.5 grams of acetic acid at 18°C. , what will be the percentage strength of the acid?

942. How many grams of absolute acetic acid in 600 cc. of acid having a specific gravity of 1.0350 at 28°C. ?

943. What is the per cent. by weight of absolute alcohol in a sample having a specific gravity of 0.8095?

944. What is the per cent. by volume of absolute alcohol in a sample having a specific gravity of 0.787?

945. From the U. S. P. formula for boric acid ointment find the amounts in the apothecaries system required to make one pound avoirdupois.

946. From the formula for syrup of hydriodic acid find the amounts required to make one pint.

947. From the formula for syrup of ipecac find the amounts required to make one pint.

948. From the formula for ointment of the yellow oxide of mercury find the amounts required to make one pound.

949. Find the avoirdupois weight for one gallon of a liquid having a specific gravity of 1.64.

950. How many fluidounces in 100 avoirdupois ounces of a liquid having a specific gravity of 1.36?

951. How many fluidounces in 1000 grains of a liquid having a specific gravity of 0.92?

952. How many grains in a fluidounce of chloroform? What is its specific volume?

953. What is the volume in U. S. wine measure of 6000 cc.?

954. How many cubic centimeters in three pints?

955. How many cubic centimeters in one gallon?

119. Miscellaneous Problems

956. In what proportion must 25 per cent., 38 per cent. and 92 per cent. alcohols be mixed to produce 45 per cent. alcohol?

957. How many grains of cocaine hydrochloride will be required to make 2 fluidounces of a 4 per cent. solution?

958. How many grains of mercuric chloride will be required to make a gallon of solution containing 1 grain in 10,000 minims?

959. How many fluidounces of glycerin in 10 pounds of solution containing 30 per cent. of glycerin?

960. What is the volume capacity of a can which holds 25 lbs. of ether?

961. When 100 grains of a substance are placed in a counterpoised bottle and filled with water, the whole weighs 1088 grains. The capacity of the bottle is 1000 grains of water. What is the specific gravity of the substance?

962. One pound of shot is put into a bottle and filled with water. The total weight is 25,566 grains. The bottle filled with water weighs 19,174 grains. What is the specific gravity of the shot?

963. A piece of potassium dichromate weighs 120 grams in air and 64 grams in alcohol. What is the specific gravity of the potassium dichromate?

964. What is the specific gravity of a piece of metal which is 3 dm. long, 12.5 cm. wide and 8 cm. thick and weighs 23,400 grams?

965. If vanilla costs nine dollars a pound, sugar six cents a pound and alcohol three dollars and fifty cents a gallon, what will five gallons of Tincture of Vanilla, N.F., cost?

966. What is the strength of a solution of sodium hydroxide which requires 15 cc. of normal sulphuric acid solution to neutralize 12 grams of the solution?

967. If silver nitrate is pure, how many grams of sodium chloride will be required to precipitate all of the silver from a solution containing 15 grams of silver nitrate?

968. How much pure zinc would be required to make one pint of liquor zinci chloridi which contains 52 per cent. of zinc chloride?

969. A two fluidounce prescription contains 256 grains of chloral hydrate. The dose is 30 minims. How many grains of chloral hydrate in each dose?

970. How many fluidounces of chloroform will be displaced by two pounds of mercury?

971. How many grains of sodium bicarbonate will be required to neutralize a fluidounce of official hydrochloric acid, and how much sodium chloride will be formed?

972. A pharmacist having a call for $1/25$ of a grain of atropine

took half of a 1/50 grain tablet. How much should he have taken?

973. If one fourth pound each of chloroform and ether are mixed, what will be the weight of one fluidounce of the mixture? No allowance being made for contraction.

974. If ether costs 30 cents a pound and chloroform costs 42 cents, what will be the cost of 2 pints of a mixture having a specific gravity of 1.10, no allowance for contraction?

975. If ether costs 30 cents a pound and has a specific gravity of 0.716, what will one pint cost?

976. What will a gallon of glycerin cost at 25 cents a pound?

977. In what proportion must ether and chloroform be mixed to make a mixture having a specific gravity of 0.876, no allowance for contraction?

978. How many fluidounces each of ether and chloroform must be mixed to produce one pint of a mixture having a specific gravity of 1.000, no allowance to be made for contraction?

979. How many grams of ferrous iodide in 750 cc. of syrup of ferrous iodide (sp. gr. 1.37) if 4.3 per cent. of iodine is used in its manufacture?

980. If 60 grams of iodine are used in the manufacture of 1000 cc. of syrup of ferrous iodide, what will be the percentage of ferrous iodide in the syrup?

981. How many grains of mercuric chloride must be dissolved in a pint of water so that when one fluidram of the solution is diluted to a quart the strength shall be 1 grain to 1000 grains?

982. What is the percentage strength of a dilute hydrochloric acid obtained by diluting one liter of U. S. P. acid to 5 pounds?

983. What is the strength of a sodium chloride solution obtained by evaporating 8 pounds of a 10 per cent. solution to 2 pounds?

984. To what weight must 500 grams of 10 per cent. salt solution be evaporated to make a 16 per cent. solution?

985. What is the strength of a phenol solution containing 250 grams of phenol in 400 grams of glycerin?

986. How many pounds each of water and sucrose are required to make 12 pounds of 65 per cent. syrup?

987. If 8 fl. oz. of a stock solution contain 240 grains of potas-

sium permanganate, how many minims must be taken to make a pint of an aqueous solution containing 3 parts in 1000?

988. A pint of solution contains 4 av. oz. of potassium iodide. How many cubic centimeters must be taken to obtain 1 gram of potassium iodide?

989. How many grams of mercuric chloride will be required to make 200 cc. of a solution, 5 cc. of which when added to 445 cc. of water will make a 1 gram to 2000 cc. solution.

990. How many grains of mercuric chloride are required to make two fluidounces of a solution, one fluidram of which diluted to 8 fluidounces would make a solution containing 1 grain to 2000 minims?

991. How much physiological salt solution, containing 0.85 per cent. of sodium chloride, can be made from 10 grams of salt?

992. If four fluidounces of a solution of morphine are to be given in dessertspoonful doses, each dose to contain $1/8$ grain of morphine sulphate, how many minims of a stock solution, containing 24 grains of morphine sulphate to the ounce, will be required?

993. Solution of lead subacetate has a sp. gr. of 1.25 and contains approximately 25 per cent. of lead subacetate. How many grains in 1 fl. oz. of a solution prepared by mixing 40 cc. of the strong solution with 960 cc. of water?

994. To make 100 cc. of paregoric 4 grams of opium containing not less than 12 per cent. of morphine should be used. How many grams of opium containing only 9 per cent. should be used?

995. If you wish to use an extract containing 12 per cent. of alkaloid, in place of a drug containing 1.5 per cent. of alkaloid, how many grams extract would you use in the manufacture of one liter of tincture? The strength of the tincture to be 20 grams of drug to 100 cc. of tincture.

996. A syrupy extract of nux vomica contains 45 per cent. of moisture and 3.5 per cent. of strychnine; how much lactose should be added to 1 pound of the extract so that it will contain 5 per cent. of strychnine after it is dried?

997. How much morphine can be made from one pound of dried

opium, which was made from opium that contained 25 per cent. of moisture and 8 per cent. of morphine?

998. If moist opium containing 10.5 per cent. of morphine, loses 30 per cent. of its weight on drying, what per cent. of morphine will it contain when dry?

999. In the manufacture of extract of *nux vomica* one kilogram of drug yields 11 per cent. of dry extract, containing 27.3 per cent. of strychnine; how many grams of a mixture of magnesium oxide and starch must be added to reduce the extract to 16 per cent.?

1000. How much lactose must be added to 1 pound 7 ounces of a syrupy extract of opium which contains 32 per cent. moisture and 18 per cent. of morphine so that when it is dry it will contain 20 per cent. of morphine?

1001. How much lactose must be added to 125 grams of extract of belladonna, assaying 1.48 per cent. of alkaloids, to reduce its strength to 1.4 per cent.?

1002. How much menstruum must be added to 500 cc. of fluid-extract of cocoa, assaying 0.58 gram to 100 cc., to reduce it to the strength of 0.5 gram per 100 cc.?

1003. After extracting 25 grams of myrrh with alcohol, the residue weighed 8 grams. What is the per cent. of extract?

1004. A certain weight of oil measures 60 cc. The same weight of water measures 53 cc. What is the specific gravity of the oil?

1005. A piece of lead sulphide weighing 745 grains, specific gravity 7.45, loses 125 grains when weighed in a liquid. What is the specific gravity of the liquid?

1006. If 453.6 grams of lead shot is put into a bottle, which, if filled with water, weighs 1656 grams. The bottle when filled with water only weighs 1242 grams. What is the specific gravity of the shot?

1007. What is the capacity of a vessel which will hold 2 pounds of glycerin?

1008. What is the weight in grams of one pint of chloroform, sp. gr. 1.476?

1009. What is the weight in the *avoirdupois* system of a pint of glycerin?

1010. A bottle filled with syrup, sp. gr. 1.31, contains 25 av. ounces. How many av. ounces of chloroform will the same bottle hold?

1011. If one liter of alcohol is mixed with one liter of water, and the contraction in volume is 60 cc., what will be the per cent. by volume of alcohol?

1012. What is the length of a bar of silver 2.5 centimeters wide, 2.5 centimeters thick, its sp. gr. 10.25 and its weight 1281.25 grams.

1013. What is the weight of a piece of iron 25 inches long, 4 inches wide, 2 inches thick and its sp. gr. 7.8?

1014. When 100 grains of a substance are placed in a counterpoised bottle and it is filled with water, the whole weighs 1088 grains. The bottle holds 1000 grains of water. What is the specific gravity of the substance?

1015. If the inside diameter of a can is 9 inches, and it is filled to a depth of 10 inches with glycerin, what will be the cost of the glycerin at 30 cents a pound?

1016. A druggist proposes to exchange 5 pints of phenol, sp. gr. 1.065, at 40 cents a pound, for 5 pints of glycerin, sp. gr. 1.25, at 30 cents a pound. Would he gain or lose by the exchange, and how much?

1017. If you purchase 500 grams of ether for 45 cents, and sell 4 fluidounces for 40 cents, what per cent. profit, based on selling price, do you make?

1018. If you pay \$1.60 a kilogram for a substance and sell it for 10 cents an ounce, what is the per cent. profit based on cost?

1019. A piece of wood weighs 62.5 grams. A piece of metal weighs 94 grams in water. Both weigh 88 grams in water. What is the specific gravity of the wood?

1020. If bottles are listed at \$9.00 a gross, and a discount of 50 and 5 per cent. is allowed and an additional 2 per cent. for cash, what will be the cost if cash is paid?

1021. What will be the cost of 250 2-grain quinine capsules if quinine costs 70 cents an ounce, capsules \$1.00 per 1000 and labor 75 cents?

1022. How many gallons of water will a reservoir hold which is

7 feet deep, 30 feet wide, 36 feet long, rectangular at one end and a half circle at the other?

1023. What will be the capacity of cistern that is 8 feet deep, 7 feet in diameter, with a cone-shaped top 3 feet 6 inches high?

1024. How many fluidounces of hydrochloric acid will be required in the manufacture of a pint of solution of ferric chloride?

1025. How many grams of hydrochloric acid will be required to dissolve 15 grams of iron wire, allowing 5 per cent. for impurities?

1026. How many grams of 5 per cent. solution of sodium hydroxide will be required to neutralize 50 cc. of hydrochloric acid?

1027. How many fluidounces of dilute hydrochloric acid will be required to neutralize 24 grams of sodium bicarbonate?

1028. How many cubic centimeters of solution of potassium hydroxide will be required to unite with 50 cc. of 10 per cent. nitric acid?

1029. How many cubic centimeters each of solution of potassium hydroxide and 10 per cent. sulphuric acid will be required to form 150 grams of potassium sulphate?

1030. How many fluidounces of 10 per cent. hydrochloric acid and 10 per cent. ammonia water must be taken to form 55 grams of ammonium chloride?

1031. How many cubic centimeters of 10 per cent. sulphuric acid must be used to completely precipitate the barium from 12 grams of barium chloride?

1032. How many cubic centimeters of acetic acid and 5 per cent. solution of sodium hydroxide will be required to make a pound of 20 per cent. solution of sodium acetate?

1033. Solution of tersulphate of iron contains 10 per cent. of iron. What per cent. of iron tersulphate does it contain?

1034. If 80 grams of solution of tersulphate of iron, containing 10 per cent. of iron, are used in the manufacture of magma of ferric hydroxide, how many cubic centimeters of ammonia water will be required to precipitate the hydroxide?

1035. How many grams of ferric hydroxide can be obtained from 50 cc. of solution of iron tersulphate?

1036. How many grams of sodium hydroxide must be used to make magma magnesia from 75 grams of magnesium sulphate?

1037. How many grams of magnesium oxide can be prepared by igniting 40 grams of magnesium carbonate?

1038. How many grams of magnesium carbonate can be prepared from 25 grams of magnesium sulphate?

1039. How many grains of zinc sulphate can be prepared from 300 grains of metallic zinc?

1040. How many grains of zinc sulphate can be prepared by the action of 2 fluidounces of 10 per cent. sulphuric acid on metallic zinc?

1041. Theoretically, how many grams of crystallized sulphate of iron can be formed by the action of 100 cc. of 10 per cent. sulphuric acid on iron wire?

1042. How many grams of solution of tersulphate of iron can be formed by the action of 25 grams of sulphuric acid on iron wire, which first forms ferrous sulphate. Then how many grams more acid must be added to form the tersulphate, when oxidized by nitric acid?

1043. How many grams of zinc chloride can be formed by the action of 2 fluidounces of hydrochloric acid on metallic zinc?

1044. A prescription calls for sodium bromide, which is not in stock. How much hydrobromic acid and sodium bicarbonate must be taken to form 180 grains?

1045. How many grains of hydrobromic acid and lithium carbonate must be taken to form 320 grains of lithium bromide?

1046. How many grains of sodium carbonate will be required to neutralize 120 grains of salicylic acid, and how much sodium salicylate will be formed?

1047. How many grams of potassium bitartrate will be formed by neutralizing 4 fluidounces of 5 per cent. potassium hydroxide with tartaric acid? How much tartaric acid will be required?

1048. Find the amount of glacial acetic acid and sodium bicarbonate required to form 90 grains of sodium acetate.

1049. Find the number of grains of potassium citrate that will be formed by neutralizing 2 fluidounces of a 5 per cent. solution of potassium hydroxide with citric acid, and find how much acid will be required.

1050. How many grams of ammonium bicarbonate can be formed from 15 grams of ammonium carbonate?

1051. How many grams of potassium chlorate must be used to fill a tank 3 feet in diameter and 4 feet high with oxygen gas?

1052. How many cubic feet of oxygen gas can be formed from one pound of potassium chlorate?

1053. How much calcium carbonate will be required to fill a tank, having the capacity of 100 gallons of water, with carbon dioxide?

1054. What is the purity of yellow mercurous oxide when 500 milligrams yield by electrolytic assay 300 milligrams of metallic mercury?

1055. If three grams of mercuric iodide are decomposed by the electrolytic method, how much metallic mercury will be formed?

1056. What is the purity of zinc chloride if when assayed by the electrolytic method 0.3 gram yields 145 milligrams of pure zinc?

1057. How much impurities does zinc acetate contain if when assayed 500 milligrams yield 140 milligrams of metallic zinc?

1058. What per cent. of crystallized magnesium sulphate is anhydrous magnesium sulphate?

1059. If one gram of crystallized magnesium sulphate is assayed and 0.455 gram of magnesium pyrophosphate is obtained, what per cent. is pure sulphate of magnesia?

1060. If 104 milligrams of calcium oxide are obtained from 400 milligrams of calcium glycerophosphate, what per cent. of pure glycerophosphate is present in the sample?

1061. How many grams of glycerophosphoric acid are required to make 150 grams of calcium glycerophosphate?

1062. What per cent. of calcium glycerophosphate is calcium oxide?

1063. If 4 grams of magnesium oxide are assayed for calcium oxide, and the residue of calcium oxide obtained weighs 35 milligrams, what per cent. of calcium oxide is present in the magnesium oxide?

1064. If two per cent. of calcium oxide is present in a sample of magnesium oxide, and one gram of the magnesium oxide

requires 48.5 cc. of normal sulphuric acid to complete the assay, what per cent. of pure magnesium oxide does the sample contain?

1065. If one gram of ferric chloride requires 35 cc. of N/10 thiosulphate for the end reaction, what per cent. of iron does it contain? What per cent. of chloride of iron is the iron equivalent to?

1066. If 500 milligrams of mercuric oxide yield 846 milligrams of mercuric sulphide, what is the purity of the sample?

1067. How much mercuric sulphide can be obtained from 15 grams of mercuric chloride?

1068. How many grams of metallic mercury can be obtained from a pound of mercuric sulphide?

1069. How many ounces of mercuric chloride should be obtained from $\frac{1}{2}$ pound of metallic mercury by treating with an excess of hydrochloric acid?

1070. How many grams of mercuric sulphate should be required to make $\frac{1}{4}$ pound of mercurous chloride? No allowance being made for loss.

TABLES

120. Saturation Tables

Answers to the problems which follow may be obtained from the Saturation Tables. An example may serve to illustrate their use.

A prescription calls for 120 grains of sodium benzoate, which is not in stock. The dispenser turns to Saturation Table III, under Sodium Salts, and in the first column, third line, he finds sodium benzoate. By following the line through he finds that it requires 58.32 parts, or grains, of sodium bicarbonate and 84.73 parts, or grains, of benzoic acid to make 100 grains of sodium benzoate. As 120 grains, the required amount, is 1.2 times 100, he takes 1.2 times the above amounts, or 69.98 grains of sodium bicarbonate and 101.67 grains of benzoic acid. If the prescription calls for a liquid, all that is necessary is to dissolve the two substances in the liquid and when effervescence ceases it is ready for use. If a dry powder is wanted, the two substances may be moistened with a small quantity of water and stirred until effervescence ceases, then dry at a low temperature.

The author has found these tables very convenient when preparing questions for written exercises, as the following problems may serve to illustrate.

Problems

1071. How many grams each of sodium bicarbonate and dilute acetic acid will be required to make 5 grams of sodium acetate?

1072. How many grains each of salicylic acid and monohydrated sodium carbonate will be required to make 5 drams of sodium salicylate?

1073. How many ounces each of sodium bicarbonate and benzoic acid must be taken to make 10 ounces of sodium benzoate?

1074. In order to make a kilogram of ammonium citrate, how many grams of ammonium carbonate and citric acid must be taken?

1075. How many grains of potassium carbonate and diluted hydrobromic acid will be required to make 4 ounces of a solution containing a dram of potassium bromide to the ounce?

1076. If a prescription calls for a dram of ammonium benzoate, which is not in stock, from what can it be made and what quantities must be taken?

1077. How many grams of potassium carbonate will be required to neutralize 25 grams of lactic acid, and what will be the weight of the potassium lactate formed?

1078. How many grains of ammonium carbonate will unite with 5 scruples of hydrochloric acid and what will be the weight of the product?

1079. What will be the weight, in grains, of benzoic acid necessary to neutralize 2 drams of sodium bicarbonate, and how many grains of sodium benzoate will be formed?

In the following Saturation Tables there are answers to 758 additional chemical problems.

SATURATION TABLES

I. Table Showing the Quantity of Official Alkalies Required to Saturate 100 Parts of Official Acid, together with the Quantity of Product.

Acids	Offi- cial Per Cent.	Ammonium				Potassium					Sodium				
		Carbonate	Ammon. Water 10%	Ammon. Water 28%	Product	Potassium Hydroxide 85%	Sol. of Po- tassium 5%	Potassium Bicar- bonate	Potassium Carbonate	Product	Sodium Hydroxide 90%	Sol. of Sodium 5%	Sodium Bicarbon- ate	Mono-Hy- drat. So- dium Carb.	Product
Acetic.	36.0	31.41	102.15	36.48	46.22	39.59	672.98	60.04	41.44	58.84	26.66	470.88	50.38	37.19	81.60
Acetic, diluted.	6.0	5.23	17.03	6.08	7.70	6.60	112.16	10.01	6.91	9.81	4.44	79.98	8.40	6.20	13.60
Acetic, glacial.	103.0	87.24	283.76	101.34	128.39	109.97	1869.40	166.77	115.11	163.45	74.06	1333.00	139.95	103.30	226.67
Benzoic.	100.0	42.91	139.57	49.85	113.95	54.09	919.46	82.02	56.62	175.49	36.42	655.63	63.83	50.81	118.02
Citric.	100.0	74.79	243.25	86.88	115.75	94.27	1602.53	143.01	98.68	154.40	63.48	1142.71	119.97	88.55	170.00
Hydrobromic, diluted.	10.0	6.47	21.05	7.52	12.10	8.16	138.66	12.37	8.54	14.71	5.49	98.88	10.38	7.66	12.72
Hydrochloric.	31.9	45.81	149.00	53.22	46.79	57.74	981.58	87.57	60.44	65.22	38.88	699.93	73.48	54.24	51.13
Hydrochloric, diluted.	10.0	14.36	46.71	16.69	14.67	18.10	307.71	27.45	18.95	20.44	12.19	219.41	23.04	17.00	16.03
Lactic.	87.5	50.89	165.51	59.11	104.04	64.04	1090.42	97.27	67.14	124.50	43.20	777.54	81.63	60.26	108.87
Nitric.	68.0	56.51	183.80	65.64	86.38	71.23	1210.88	108.02	74.56	109.10	47.97	863.43	90.65	66.91	91.73
Nitric, diluted.	10.0	8.31	27.03	9.65	12.70	10.47	178.07	15.89	10.97	16.04	7.05	126.98	13.33	9.84	13.49
Phosphoric.	86.5	92.42	300.51	107.32	116.54	116.45	1979.72	176.92	121.91	153.70	78.77	1411.79	148.20	109.42	316.09
Phosphoric, diluted.	10.0	11.01	34.74	12.41	13.47	13.46	228.88	20.42	14.09	17.77	9.07	163.20	17.13	12.65	36.53
Salicylic.	100.0	37.94	123.39	44.07	112.34	47.82	812.89	72.52	50.05	127.59	32.20	579.65	60.86	44.92	115.93
Sulphuric.	94.0	100.36	326.41	116.57	126.61	126.49	2150.57	191.83	132.40	166.97	85.18	1533.33	160.98	118.92	308.73
Sulphuric, diluted.	10.0	10.68	34.73	12.40	13.47	13.46	228.81	20.41	14.09	17.77	9.00	163.10	17.13	12.94	32.85
Tartaric.	100.0	69.81	227.04	81.09	122.71	87.99	1495.77	133.44	92.11	156.77	59.25	1066.58	111.98	82.65	153.32
Arsenic trioxide. ....	.....	52.92	172.13	61.48	126.31	66.70	1133.97	101.16	69.83	147.60	44.92	808.61	84.89	62.66	131.33

SATURATION TABLES

III. Table Showing the Quantity of Official Alkalies and Acids Required to make 100 Parts of the Corresponding Salts.

(a) Ammonium Salts

AMMONIUM SALTS	Parts of Alkali Required				ACID	
	Ammonium Carbonate 100%	Ammonia Water 10%	Ammonia Water 28%	Parts Required	Official Per Cent.	
Ammonium acetate, $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$	67.96	221.02	78.94	{ 216.36	Acetic acid	36.0
Ammonium arsenite, NH_4AsO_2				{ 1298.16	Acetic acid, diluted	6.0
Ammonium benzoate, $\text{NH}_4\text{C}_7\text{H}_5\text{O}_2$	41.90	136.27	48.67	77.89	Acetic acid, glacial	100.0
Ammonium bromide, NH_4Br	37.66	122.47	43.74	79.17	Arsenic acid	100.0
Ammonium chloride, NH_4Cl	53.46	173.88	62.10	87.76	Benzoic acid	100.0
Ammonium citrate, $(\text{NH}_4)_3\text{C}_6\text{H}_5\text{O}_7$	97.89	318.38	113.71	826.15	Hydrobromic acid, diluted	10.0
Ammonium citrate, $(\text{NH}_4)_3\text{C}_6\text{H}_5\text{O}_7$				{ 213.69	Hydrochloric acid	31.9
Ammonium lactate, $\text{NH}_4\text{C}_3\text{H}_5\text{O}_3$	64.61	210.15	75.05	681.68	Hydrochloric acid, diluted	10.0
Ammonium nitrate, NH_4NO_3	48.91	159.07	56.81	86.39	Citric acid	100.0
	65.43	212.79	76.00	96.11	Lactic acid	87.5
Ammonium phosphate, $(\text{NH}_4)_2\text{HPO}_4$	79.28	257.83	92.08	115.77	Nitric acid	68.0
Ammonium salicylate, $\text{NH}_4\text{C}_7\text{H}_5\text{O}_3$	33.77	109.84	39.23	787.26	Nitric acid, diluted	10.0
Ammonium sulphate, $(\text{NH}_4)_2\text{SO}_4$	79.26	257.80	92.07	85.79	Phosphoric acid	86.5
Ammonium tartrate, $(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$	56.89	185.03	66.08	742.15	Phosphoric acid, diluted	10.0
				89.02	Salicylic acid	100.0
				{ 78.96	Sulphuric acid	94.0
				{ 742.26	Sulphuric acid, diluted	10.0
				81.50	Tartaric acid	100.0

SATURATION TABLES

III. Continuation of Table Showing the Quantity of Official Alkalies and Acids Required to make 100 Parts of the Corresponding Salts.

(b) Potassium Salts

POTASSIUM SALTS	Parts of Alkali Required					ACID	
	Potassium Hydroxide 85%	Sol. of Potassium Hydroxide 5%	Potassium Bicarbonate 100%	Potassium Carbonate 100%	Parts Required	Official Per Cent.	
Potassium acetate, $\text{KC}_2\text{H}_3\text{O}_2$	= 98.12	1143.70	102.03	70.42	{ 169.95	Acetic acid	36.0
Potassium arsenite, KAsO_2	= 146.06	768.31	68.54	47.31	{ 1019.67	Acetic acid, glacial	6.0
Potassium benzoate, $\text{KC}_7\text{H}_5\text{O}_2 + \text{H}_2\text{O}$	= 214.19	523.93	46.74	32.26	{ 67.75	Arsenic trioxide	100.0
Potassium bromide, KBr	= 119.02	942.87	84.11	58.06	{ 56.98	Benzoic acid	100.0
Potassium chloride, KCl	= 74.56	1505.10	134.27	92.68	{ 679.97	Hydrobromic acid, diluted	10.0
Potassium citrate, $\text{K}_3\text{C}_6\text{H}_5\text{O}_7 + \text{H}_2\text{O}$	= 324.36	1037.92	92.59	63.91	{ 153.34	Hydrochloric acid	31.9
Potassium lactate, $\text{KC}_3\text{H}_5\text{O}_3$	= 128.14	51.52	875.76	53.93	{ 489.14	Hydrochloric acid, diluted	10.0
Potassium nitrate, KNO_3	= 101.11	65.29	78.13	53.93	{ 64.77	Citric acid	100.0
Potassium phosphate, K_3HPO_4	= 174.25	75.77	1109.88	68.34	{ 80.31	Lactic acid	87.5
Potassium salicylate, $\text{KC}_7\text{H}_5\text{O}_3$	= 176.14	637.11	56.83	39.23	{ 91.66	Nitric acid	68.0
Potassium sulphate, K_2SO_4	= 174.27	75.76	114.89	79.30	{ 623.28	Nitric acid, diluted	10.0
Potassium tartrate, $2\text{K}_2\text{C}_4\text{H}_4\text{O}_6 + \text{H}_2\text{O}$	= 470.48	56.12	85.11	58.75	{ 64.98	Phosphoric acid	86.5
					{ 562.76	Phosphoric acid, diluted	10.0
					{ 78.38	Salicylic acid	100.0
					{ 59.87	Sulphuric acid	94.0
					{ 562.86	Sulphuric acid, diluted	10.0
					{ 63.79	Tartaric acid	100.0

SATURATION TABLES
 III. Continuation of Table Showing the Quantity of Official Alkalies and Acids Required to make 100
 Parts of the Corresponding Salts.
 (c) Sodium Salts

SODIUM SALTS	Parts of Alkalies Required				Parts Required	Official Per Cent.
	Sodium Hydroxide 90 %	Sol. of Sodium Hydroxide 5 %	Sodium Bicarbon- ate 100 %	Monohy- drated So- dium Carb- 100 %		
Sodium acetate, $\text{NaC}_2\text{H}_3\text{O}_2 + 3\text{H}_2\text{O}$ = 136.07	32.67	588.08	61.74	45.57	$\left\{ \begin{array}{l} 122.55 \\ 735.28 \\ 44.12 \end{array} \right.$	$\left\{ \begin{array}{l} \text{Acetic acid} \dots\dots\dots 36.0 \\ \text{Acetic acid, diluted} \dots\dots\dots 6.0 \\ \text{Acetic acid, glacial} \dots\dots\dots 109.0 \end{array} \right.$
Sodium arsenite, NaAsO_2 = 129.96	34.21	615.73	64.64	47.72	76.15	Arsenic trioxide.....100.0
Sodium benzoate, $\text{NaC}_7\text{H}_5\text{O}_2$ = 144.04	30.86	555.54	58.32	43.05	84.73	Benzoic acid.....100.0
Sodium bromide, NaBr = 102.92	43.19	777.57	81.63	60.25	786.34	Hydrobromic acid, diluted..10.0
Sodium chloride, NaCl = 58.46	76.04	1368.80	143.71	106.07	$\left\{ \begin{array}{l} 195.55 \\ 623.85 \end{array} \right.$	$\left\{ \begin{array}{l} \text{Hydrochloric acid} \dots\dots\dots 31.9 \\ \text{Hydrochloric acid, diluted} \dots\dots\dots 10.0 \end{array} \right.$
Sodium citrate, $2\text{Na}_2\text{C}_4\text{H}_5\text{O}_7 + 11\text{H}_2\text{O}$ = 714.26	37.34	672.19	70.57	52.09	58.83	Citric acid.....100.0
Sodium lactate, $\text{NaC}_2\text{H}_3\text{O}_2$ = 112.04	39.68	714.21	74.98	55.35	91.84	Lactic acid.....87.5
Sodium nitrate, NaNO_3 = 85.01	52.30	941.30	98.82	72.94	$\left\{ \begin{array}{l} 109.02 \\ 741.33 \end{array} \right.$	$\left\{ \begin{array}{l} \text{Nitric acid} \dots\dots\dots 68.0 \\ \text{Nitric acid, diluted} \dots\dots\dots 10.0 \end{array} \right.$
Sodium phosphate, $\text{Na}_2\text{HPO}_4 + 12\text{H}_2\text{O}$ = 358.24	24.82	446.74	46.90	34.62	$\left\{ \begin{array}{l} 31.60 \\ 273.73 \end{array} \right.$	$\left\{ \begin{array}{l} \text{Phosphoric acid} \dots\dots\dots 86.5 \\ \text{Phosphoric acid, diluted} \dots\dots\dots 10.0 \end{array} \right.$
Sodium salicylate, $\text{NaC}_7\text{H}_5\text{O}_3$ = 160.04	27.76	500.00	52.49	38.75	86.26	Salicylic acid.....100.0
Sodium sulphate, $\text{Na}_2\text{SO}_4 + 10\text{H}_2\text{O}$ = 322.23	27.59	496.66	52.14	38.49	$\left\{ \begin{array}{l} 31.67 \\ 304.41 \end{array} \right.$	$\left\{ \begin{array}{l} \text{Sulphuric acid} \dots\dots\dots 94.0 \\ \text{Sulphuric acid, diluted} \dots\dots\dots 10.0 \end{array} \right.$
Sodium tartrate, $\text{Na}_2\text{C}_4\text{H}_4\text{O}_6 + 2\text{H}_2\text{O}$ = 230.06	38.65	695.65	73.03	53.91	65.22	Tartaric acid.....100.0

CONVERSION TABLES

The following tables, by Dr. A. B. Lyons, will be found especially valuable for converting the strengths of preparations from one system of weights and measures to those of another. Example: We desire to know the strength, in the metric system, of a preparation that contains 120 grains in a fluidounce. Under grains per fluidounce, we find 20 and opposite under gram per liter we find 43.9; also opposite 100 we find 219.5; $43.9 \div 219.5 = 0.199$, the number of grams in a liter that are equal to 120 grains in a fluidounce.

GRAINS PER FLUIDOUNCE EQUIVALENT TO GRAMS
PER LITER

Grains per Fluid Oz.	Grams per Liter.	Grains per Fluid Oz.	Grams per Liter	Grains per Fluid Oz.	Grams per Liter
1	2.2	9	19.8	80	175.6
2	4.4	10	22.0	90	197.5
3	6.6	20	43.9	100	219.5
4	8.8	30	65.9	200	439.0
5	11.0	40	87.8	300	658.5
6	13.2	50	109.8	400	878.0
7	15.4	60	131.7	500	1097.5
8	17.6	70	153.6	600	1316.9

GRAINS PER FLUIDRAM EQUIVALENT TO GRAMS
PER LITER

Grains per Fluid Dr.	Grams per Liter	Grains per Fluid Dr.	Grams per Liter	Grains per Fluid Dr.	Grams per Liter
1	17.6	7	122.9	40	702.4
2	35.1	8	140.5	50	878.0
3	52.7	9	158.0	60	1053.6
4	70.2	10	175.6	70	1229.1
5	87.8	20	351.2	80	1404.7
6	105.4	30	526.8		

MINIMS PER FLUIDOUNCE EQUIVALENT TO CUBIC CENTI-METERS PER LITER

Minims per Fluid Oz.	Cubic Centi-meters per Liter	Minims per Fluid Oz.	Cubic Centi-meters per Liter	Minims per Fluid Oz.	Cubic Centi-meters per Liter
1	2.1	9	18.8	80	166.7
2	4.2	10	20.8	90	187.5
3	6.3	20	41.7	100	208.3
4	8.3	30	62.5	200	416.7
5	10.4	40	83.3	300	625.0
6	12.5	50	105.2	400	833.3
7	14.6	60	125.0	480	1000.0
8	16.7	70	145.8		

MINIMS PER FLUIDRAM EQUIVALENT TO CUBIC CENTI-METERS PER LITER

Minims per Fluid Dr.	Cubic Centi-meters per Liter	Minims per Fluid Dr.	Cubic Centi-meters per Liter	Minims per Fluid Dr.	Cubic Centi-meters per Liter
1	16.7	6	100.0	20	333.3
2	33.3	7	116.7	30	500.0
3	50.0	8	133.3	40	666.7
4	66.7	9	150.0	50	833.3
5	83.3	10	166.7	60	1000.0

**CUBIC CENTIMETERS PER LITER, EQUIVALENT TO MINIMS,
ETC., PER GALLON**

Cubic Cen- timeters per Liter	Minims, Etc., per Gallon			Minims, Etc., per Pint		Minims per Fl. Oz.	Minims per Fl. Drm.
	Lb.	Fl. Oz.	Min.	Fl. Oz.	Min.	Minims	Minims
1	..	..	61.4	..	7.7	0.5	0.06
2	..	..	122.9	..	15.4	1.0	0.12
3	..	..	184.3	..	23.0	1.4	0.18
4	..	..	245.8	..	30.7	1.9	0.24
5	..	..	307.2	..	38.4	2.4	0.30
6	..	..	368.6	..	46.1	2.9	0.36
7	..	..	430.1	..	53.8	3.4	0.42
8	..	1	11.5	..	61.4	3.8	0.48
9	..	1	73.0	..	69.1	4.3	0.54
10	..	1	134	..	76.8	4.8	0.6
20	..	2	269	..	153.6	9.6	1.2
30	..	3	403	..	230.4	14.4	1.8
40	..	5	58	..	307.2	19.2	2.4
50	..	6	192	..	384.0	24.0	3.0
60	..	7	326	..	460.8	28.8	3.6
70	..	8	461	1	57.6	33.6	4.2
80	..	10	115	1	134.4	38.4	4.8
90	..	11	250	1	211.2	43.2	5.4
100	..	12	384	1	288	48	6
200	1	9	288	3	96	96	12
300	2	6	192	4	384	144	18
400	3	3	96	6	192	192	24
500	4	0	0	8	0	240	30
600	4	12	384	9	288	288	36
700	5	9	288	11	96	336	42
800	6	6	192	12	384	384	48
900	7	3	96	14	192	432	54
1000	8	0	0	16	0	480	60

**GRAMS PER LITER, EQUIVALENT TO GRAINS, ETC., PER
GALLON**

Grams per Liter	Grains, Etc., per Gallon			Grains, Etc., per Pint		Grains per Fl. Oz.	Grains per Fl. Drm.
	Lb.	Oz.	Gr.	Oz.	Gr.	Gr.	Gr.
1	..	..	58.3	..	7.3	0.5	0.06
2	..	..	116.6	..	14.6	0.9	0.11
3	..	..	175.0	..	21.9	1.4	0.17
4	..	..	233.3	..	29.2	1.8	0.23
5	..	..	291.6	..	36.5	2.3	0.29
6	..	..	349.9	..	43.7	2.7	0.34
7	..	..	408.2	..	51.0	3.2	0.40
8	..	1	29.1	..	58.3	3.6	0.46
9	..	1	87.4	..	65.6	4.1	0.51
10	..	1	146	..	72.9	4.6	0.57
20	..	2	291	..	145.8	9.1	1.14
30	..	3	437	..	218.7	13.7	1.71
40	..	5	145	..	291.6	18.2	2.28
50	..	6	291	..	364.5	22.8	2.85
60	..	7	437	..	437.4	27.3	3.42
70	..	9	145	1	72.8	31.9	3.99
80	..	10	291	1	145.7	36.5	4.56
90	..	11	436	1	218.6	41.0	5.13
100	..	13	145	1	292	45.6	5.7
200	1	10	289	3	146	91.1	11.4
300	2	7	434	4	437	136.7	17.1
400	3	5	141	6	291	182.2	22.8
500	4	2	285	8	145	227.8	28.5
600	4	15	430	9	437	273.4	34.2
700	5	13	137	11	290	318.9	39.9
800	6	10	181	13	145	364.5	45.6
900	7	7	426	14	436	410.0	51.3
1000	8	5	133	16	290	455.6	57.0

Tables giving the quantities by weight or measure required to make one gallon of a mixture, each fluidram of which is to contain a given dose. The same table may be used to make one pint by dividing the quantity by eight.

Dose in Grains	Quantity per Gallon		Dose in Grains	Quantity per Gallon			Dose in Minims	Quantity per Gallon		
	Oz.	Grains		Lb.	Oz.	Grains		Pts.	Fl.Oz.	Min.
1/1000	..	1.02	0.01	..	..	10.24	1/8	..	..	128
1/500	..	2.05	0.02	..	..	20.48	1/4	..	..	256
1/400	..	2.56	0.03	..	..	30.72	1/3	..	..	341.3
1/350	..	2.93	0.04	..	..	40.96	3/8	..	..	384
1/333	..	3.07	0.05	..	..	51.20	1/2	..	1	32
1/320	..	3.20	0.06	..	..	61.44	5/8	..	1	160
1/300	..	3.41	0.07	..	..	71.68	2/3	..	1	202.6
1/250	..	4.10	0.08	..	..	81.92	3/4	..	1	288
1/240	..	4.27	0.09	..	..	92.16	7/8	..	1	416
1/200	..	5.12	0.1	..	..	102.4	1	..	2	64
1/160	..	6.40	0.2	..	..	204.8	2	..	4	128
1/150	..	6.83	0.3	..	..	307.2	3	..	6	192
1/128	..	8	0.4	..	..	409.6	4	..	8	256
1/100	..	10.24	0.5	..	1	74.5	5	..	10	320
1/90	..	11.38	0.6	..	1	176.9	6	..	12	384
1/80	..	12.8	0.7	..	1	279.3	7	..	14	448
1/75	..	13.65	0.8	..	1	281.7	8	1	1	32
1/70	..	14.63	0.9	..	2	46.6	9	1	2	96
1/65	..	15.75	1	..	2	149.0	10	1	5	160
1/64	..	16	2	..	4	298.0	20	2	10	320
1/60	..	17.07	3	..	7	9.5	30	4	0	0
1/55	..	18.62	4	..	9	158.5	40	5	5	160
1/50	..	20.48	5	..	11	307.5	50	6	10	320
1/48	..	21.33	6	..	14	19.0	60	8	0	0
1/45	..	22.76	7	1	0	168.0	....	..	..	....
1/40	..	25.60	8	1	2	317.0	....	..	..	....
1/35	..	29.26	9	1	5	128.5	....	..	..	....
1/32	..	32	10	1	7	117.5	....	..	..	....
1/30	..	34.13	20	2	14	355	....	..	..	....
1/25	..	41	30	4	6	95	....	..	..	....
1/24	..	42.67	40	5	13	273	....	..	..	....
1/20	..	51.2	50	7	5	13	....	..	..	....
1/18	..	56.89	60	8	12	190	....	..	..	....
1/16	..	64	70	10	3	368	....	..	..	....
1/15	..	68.27	80	11	11	109	....	..	..	....
1/12	..	85.33	90	13	2	285	....	..	..	....
1/10	..	102.4	100	14	10	25	....	..	..	....
1/8	..	128	....	..	..	....	....	..	..	....
1/6	..	170.6	....	..	..	....	....	..	..	....
1/5	..	204.8	....	..	..	....	....	..	..	....
1/4	..	256	....	..	..	....	....	..	..	....
1/3	..	341.3	....	..	..	....	....	..	..	....
3/8	..	384	....	..	..	....	....	..	..	....
1/2	1	74.5	....	..	..	....	....	..	..	....
5/8	1	202.5	....	..	..	....	....	..	..	....
2/3	1	245.2	....	..	..	....	....	..	..	....
3/4	1	330.5	....	..	..	....	....	..	..	....
7/8	2	21	....	..	..	....	....	..	..	....

ATOMIC WEIGHTS

Adopted by the International Committee on Chemical Elements (1934)

Used in the U. S. P. XI

Aluminum.....Al	26.97	Molybdenum....Mo	96.00
Antimony.....Sb	121.76	Neodymium.....Nd	144.27
Argon.....A	39.944	Neon.....Ne	20.183
Arsenic.....As	74.91	Nickel.....Ni	58.69
Barium.....Ba	137.36	Nitrogen.....N	14.008
Beryllium.....Be	9.02	Osmium.....Os	191.5
Bismuth.....Bi	209.00	Oxygen.....O	16.000
Boron.....B	10.82	Palladium.....Pd	106.7
Bromine.....Br	79.916	Phosphorus.....P	31.02
Cadmium.....Cd	112.41	Platinum.....Pt	195.23
Calcium.....Ca	40.08	Potassium.....K	39.096
Carbon.....C	12.00	Praseodymium...Pr	140.92
Cerium.....Ce	140.13	Radium.....Ra	225.97
Cesium.....Cs	132.91	Radon.....Rn	222.0
Chlorine.....Cl	35.457	Rhenium.....Re	186.31
Chromium.....Cr	52.01	Rhodium.....Rh	102.91
Cobalt.....Co	58.94	Rubidium.....Rb	85.44
Columbium.....Cb	93.3	Ruthenium.....Ru	101.7
Copper.....Cu	63.57	Samarium.....Sm	150.43
Dysprosium....Dy	162.46	Scandium.....Sc	45.10
Erbium.....Er	165.20	Selenium.....Se	78.96
Europium.....Eu	152.0	Silicon.....Si	28.06
Fluorine.....F	19.00	Silver.....Ag	107.880
Gadolinium....Gd	157.3	Sodium.....Na	22.997
Gallium.....Ga	69.72	Strontium.....Sr	87.63
Germanium....Ge	72.60	Sulfur.....S	32.06
Gold.....Au	197.2	Tantalum.....Ta	181.4
Hafnium.....Hf	178.6	Tellurium.....Te	127.61
Helium.....He	4.002	Terbium.....Tb	159.2
Holmium.....Ho	163.5	Thallium.....Tl	204.39
Hydrogen.....H	1.0078	Thorium.....Th	232.12
Indium.....In	114.76	Thulium.....Tm	169.4
Iodine.....I	126.92	Tin.....Sn	118.70
Iridium.....Ir	193.1	Titanium.....Ti	47.90
Iron.....Fe	55.84	Tungsten.....W	184.0
Krypton.....Kr	83.7	Uranium.....U	238.14
Lanthanium....La	138.92	Vanadium.....V	50.95
Lead.....Pb	207.22	Xenon.....Xe	131.3
Lithium.....Li	6.940	Ytterbium.....Yb	173.04
Lutecium.....Lu	175.0	Yttrium.....Y	88.92
Magnesium....Mg	24.32	Zinc.....Zn	65.38
Manganese....Mn	54.93	Zirconium.....Zr	91.22
Mercury.....Hg	200.61		

List of Chemicals used in this Book, together with formulas and Molecular Weights.

Acetylene.....	CH_3CH	26.02
Acid Acetic.....	$\text{HC}_2\text{H}_3\text{O}_2$	60.03
Acid Benzoic.....	$\text{HC}_7\text{H}_5\text{O}_2$	122.05
Acid Boric.....	H_3BO_3	61.84
Acid Citric.....	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7 \cdot \text{H}_2\text{O}$	210.08
Acid Citric, dry.....	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7$	192.06
Acid Glycerophosphoric.....	$\text{H}_2\text{C}_2\text{H}_5(\text{OH})_2\text{PO}_4$	172.13
Acid Hydriodic.....	HI	127.93
Acid Hydrobromic.....	HBr	80.92
Acid Hydrochloric.....	HCl	36.47
Acid Hydrocyanic.....	HCN	27.02
Acid Nitric.....	HNO_3	63.02
Acid Nitrous.....	HNO_2	47.02
Acid Oxalic.....	$\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	126.05
Acid Oxalic, dry.....	$\text{H}_2\text{C}_2\text{O}_4$	90.03
Acid Phosphoric.....	H_3PO_4	98.04
Acid Salicylic.....	$\text{HC}_7\text{H}_5\text{O}_3$	138.05
Acid Sulfuric.....	H_2SO_4	98.08
Acid Sulfurous.....	H_2SO_3	82.08
Acid Tartaric.....	$\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	150.05
Alcohol, ethyl.....	$\text{C}_2\text{H}_5\text{OH}$	46.05
Aluminum Hydroxide.....	$\text{Al}(\text{OH})_3$	77.99
Ammonia.....	NH_3	17.03
Ammonium Carbonate (normal).....	$(\text{NH}_4)_2\text{CO}_3$	96.08
Ammonium Carbonate (U. S. P.).....	$\text{NH}_4\text{HCO}_3 \cdot \text{NH}_4\text{NH}_2\text{CO}_3$	157.11
Ammonium Chloride.....	NH_4Cl	53.50
Ammonium Citrate.....	$(\text{NH}_4)_3\text{C}_6\text{H}_5\text{O}_7$	243.19
Arsenic Sulfide.....	As_2S_5	310.12
Arsenous Oxide (Arsenic Trioxide).....	As_2O_3	197.82
Arsine.....	AsH_3	77.93
Barium Carbonate.....	BaCO_3	197.36
Barium Chloride.....	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$	244.31
Barium Chloride, dry.....	BaCl_2	208.27
Barium Sulfate.....	BaSO_4	233.41
Calcium Carbonate.....	CaCO_3	100.08
Calcium Chloride.....	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$	219.09
Calcium Chloride.....	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$	147.03
Calcium Chloride, dry.....	CaCl_2	110.99
Calcium Glycerophosphate.....	$\text{CaC}_3\text{H}_7\text{PO}_6$	210.15
Calcium Oxide.....	CaO	56.07
Carbon Dioxide.....	CO_2	44.00
Cocaine.....	$\text{C}_{17}\text{H}_{21}\text{NO}_4$	303.17
Cupric Sulfate.....	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	249.71
Cupric Sulfate, dry.....	CuSO_4	159.63
Ethyl Nitrite.....	$\text{C}_2\text{H}_5\text{NO}_2$	75.05
Ethyl Oxide (Ether).....	$(\text{C}_2\text{H}_5)_2\text{O}$	74.08
Ferric Chloride.....	$\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$	270.30
Ferric Chloride, dry.....	FeCl_3	162.21

Ferric Oxide.....	Fe_2O_3	159.68
Ferric Sulfate.....	$\text{Fe}_2(\text{SO}_4)_3$	399.86
Ferrous Bromide, dry.....	FeBr_2	215.67
Ferrous Bromide.....	$\text{FeBr}_2 \cdot 6\text{H}_2\text{O}$	323.77
Ferrous Carbonate.....	FeCO_3	115.84
Ferrous Iodide.....	FeI_2	309.68
Ferrous Sulfate.....	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	278.01
Ferrous Sulfate, dry.....	FeSO_4	151.90
Hydrogen Dioxide.....	H_2O_2	34.02
Hydrogen Sulfide.....	H_2S	34.08
Lead Acetate.....	$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$	379.31
Lead Acetate, dry.....	$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$	325.27
Lead Chloride.....	PbCl_2	278.13
Lead Iodide.....	PbI_2	461.06
Lead Oxide.....	PbO	223.22
Lead Sulfate.....	PbSO_4	303.28
Lead Sulfide.....	PbS	239.28
Lithium Carbonate.....	Li_2CO_3	73.88
Magnesium Carbonate (approx.).....	$(\text{MgCO}_3) \cdot \text{Mg}(\text{OH})_2 \cdot 5\text{H}_2\text{O}$	485.69
Magnesium Oxide.....	MgO	40.32
Magnesium Sulfate.....	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	246.49
Magnesium Sulfate, dry.....	MgSO_4	120.38
Mercuric Chloride.....	HgCl_2	271.52
Mercuric Oxide.....	HgO	216.61
Mercurous Chloride.....	HgCl	236.07
Methane.....	CH_4	16.03
Morphine.....	$\text{C}_{17}\text{H}_{19}\text{NO}_5 \cdot \text{H}_2\text{O}$	303.17
Morphine, dry.....	$\text{C}_{17}\text{H}_{19}\text{NO}_5$	285.16
Nitrogen Dioxide.....	NO_2	46.01
Nitric Oxide.....	NO	30.01
Nitrous Oxide.....	N_2O	44.02
Ozone.....	O_3	48.00
Paraldehyde.....	$\text{C}_6\text{H}_{12}\text{O}_3$	132.09
Phosphine.....	PH_3	34.04
Potassium Bicarbonate.....	KHCO_3	100.10
Potassium Bromide.....	KBr	119.01
Potassium Carbonate.....	K_2CO_3	138.19
Potassium Chlorate.....	KClO_3	122.55
Potassium Chloride.....	KCl	74.55
Potassium Citrate.....	$\text{K}_3\text{C}_6\text{H}_5\text{O}_7 \cdot \text{H}_2\text{O}$	324.34
Potassium Citrate, dry.....	$\text{K}_3\text{C}_6\text{H}_5\text{O}_7$	306.33
Potassium Cyanide.....	KCN	65.10
Potassium Hydroxide.....	KOH	56.10
Potassium Hypophosphite.....	KPH_2O_2	104.13
Potassium Iodide.....	KI	166.02
Potassium Permanganate.....	KMnO_4	158.03
Potassium Phosphate.....	K_2HPO_4	174.22
Potassium Sulphocyanide.....	KSCN	97.16
Silver Chloride.....	AgCl	143.34
Silver Cyanide.....	AgCN	133.89
Silver Iodide.....	AgI	234.80
Silver Nitrate.....	AgNO_3	169.89

Sodium Bicarbonate.....	NaHCO_3	84.00
Sodium Carbonate.....	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	286.15
Sodium Carbonate, Monohydrated.....	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	124.01
Sodium Carbonate dry.....	Na_2CO_3	105.99
Sodium Chloride.....	NaCl	58.45
Sodium Hydroxide.....	NaOH	40.00
Sodium Hyposulfite (Thiosulfate).....	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	248.19
Sodium Iodide.....	NaI	149.92
Sodium Nitrate.....	NaNO_3	85.01
Sodium Nitrite.....	NaNO_2	69.01
Sodium Phosphate.....	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$	358.24
Sodium Phosphate, dry.....	Na_2HPO_4	142.02
Sodium Salicylate.....	$\text{NaC}_7\text{H}_5\text{O}_3$	160.04
Sodium Sulfate.....	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	322.21
Sodium Sulfate, dry.....	Na_2SO_4	142.05
Sodium Sulfite.....	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	252.16
Sodium Sulfite, dry.....	Na_2SO_3	126.05
Sulfur Dioxide.....	SO_2	64.06
Sulfur Trioxide.....	SO_3	80.06
Water.....	H_2O	18.016
Zinc Chloride.....	ZnCl_2	136.29
Zinc Sulfate.....	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	287.55
Zinc Sulfate, dry.....	ZnSO_4	161.44

Specific Gravities and Percentages of Some Preparations
Used in this Book

	Sp. Gr.	Per Cent.
Acetone.....	0.79	99
Acid acetic, glacial.....	1.05	99
Acid acetic.....	1.045	36
Acid acetic, dilute.....	1.008	6
Acid hydrobromic, dilute.....	1.076	10
Acid hydrochloric.....	1.175	36
Acid hydrochloric, dilute.....	1.046	10
Acid hydriodic, dilute.....	1.1	10
Acid lactic.....	1.206	87.5
Acid nitric.....	1.403	68
Acid nitric, dilute.....	1.055	10
Acid oleic.....	0.895	
Acid phosphoric.....	1.71	85
Acid phosphoric, dilute.....	1.057	10
Acid sulphuric.....	1.84	94
Acid sulphuric, aromatic.....	0.95	20
Acid sulphuric, dilute.....	1.064	10
Alcohol absolute.....	0.798	99
Alcohol.....	0.816	93
Alcohol, dilute.....	0.935	41.5
Ammonia water.....	0.957	10
Ammonia water, stronger.....	0.897	28
Chloroform.....	1.475	
Ether.....	0.715	
Glycerin.....	1.25	
Mercury.....	13.5	
Oil of Peppermint.....	0.908	
Oil of Turpentine.....	0.865	
Olive Oil.....	0.91	
Solution of aluminum acetate.....	1.022	5
Solution of ferric chloride.....	1.29	10
Solution ferric subsulphate.....	1.548	13.5
Solution ferric tersulphate.....	1.432	10
Solution potassium hydroxide.....	1.046	5
Solution sodium hydroxide.....	1.056	5
Solution zinc chloride.....	1.548	50

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